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National Security and
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January 29, 1991

The Honorable Sam Nunn
Chairman, Committee on
Armed Services
United States Senate

The Honorable Mary Rose Oakar
Chair, Subcommittee on
Economic Stabilization
Committee on Banking, Finance
and Urban Affairs
House of Representatives

The Honorable Howard M. Metzenbaum
United States Senate



In response to your several requests, we assessed a number of issues concerning the explosion aboard the Iowa and the overall battleship program. These issues addressed the Navy's technical investigation of the explosion; the serviceability, supportability, and safety of the battleships' 16-inch guns and ammunition; the battleships' manning levels and training of assigned personnel; the gunnery experiments that were being conducted on board the Iowa; and the battleship employment plan.

We are sending copies of this report to the Chairmen, Senate Committee on Governmental Affairs, House Committee on Government Operations, and Senate and House Committees on Appropriations; the Director, Office of Management and Budget; and the Secretaries of Defense and the Navy.

This report was prepared under the direction of Martin Ferber, Director, Navy Issues, who can be reached on (202) 275-6504 if you or your staff have any questions. Other major contributors are listed in appendix III.

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# Executive Summary

## Purpose

On April 19, 1989, 47 sailors died when five bags of propellant ignited in the open chamber of the center 16-inch gun of the battleship U.S.S. Iowa's turret II. The Navy's investigation concluded that the explosion resulted from a deliberate act and not from a defect in the gun or propellant.

The Chairman, Senate Committee on Armed Services; the Chair, Subcommittee on Economic Stabilization, House Committee on Banking, Finance and Urban Affairs; and the Honorable Howard M. Metzenbaum, U.S. Senate; asked GAO to examine several issues concerning the explosion and the overall battleship program. They asked GAO to (1) independently investigate the Navy's technical analysis of likely causes of the explosion; (2) examine the safety, serviceability, and supportability of ammunition and equipment; (3) examine issues related to manning and training on the battleships; and (4) review the battleships' employment plans and mission.

## Background

The Navy based its conclusion on its analysis of material it found on the rotating band of the projectile that lodged in the gun barrel during the explosion. It also relied on a psychological analysis the Federal Bureau of Investigation prepared that indicated that a crew member was capable of making and using such a device.

GAO asked the Department of Energy's Sandia National Laboratories to review the Navy's technical analysis.

## Results in Brief

Sandia could neither confirm nor deny the Navy's conclusion that a deliberate act by a crew member caused the Iowa explosion, nor could it prove or disprove the Navy's contention that foreign material on the rotating band was evidence of an improvised explosive device used to ignite the powder charge. Moreover, Sandia is confident in its findings that the foreign materials found in turret II on the Iowa were consistent with the nominal levels found throughout gun turrets and the maritime environment. However, Sandia identified a plausible alternative explanation for the explosion—because of its impact sensitivity, the gunpowder could have ignited as the result of a high-speed overram against the base of the projectile.

As a result, the Navy halted all firings of the 16-inch guns. With Sandia's assistance, it is doing further testing. On the basis of that testing, and because of the battleships' role in Operation Desert Shield,

the Navy has lifted the firing suspension for the battleships U.S.S. Missouri and U.S.S. Wisconsin.

GAO found no evidence of any systemic safety or serviceability problems aboard the battleships. GAO did find problems with the adequacy of supervisory personnel manning levels, including the personnel responsible for operating the turrets, and with training for 16-inch gun operations. The Navy's investigation report and a subsequent Navy Inspector General's report also found that safety policies and procedures had not been followed and that improperly approved gunpowder experimentation was taking place at the time of the explosion.

Finally, GAO evaluated the employment plans and the mission for the battleships. GAO noted that, except for the 16-inch guns, other types of ships have warfare capabilities similar to those of the battleships. Moreover, emerging circumstances such as changing military doctrine and budget constraints—which resulted in the Secretary of Defense directing the Navy to decommission two of the four battleships—make the two remaining battleships top candidates for decommissioning.

# GAO's Analysis

## Chemical and Impact Sensitivity Issues

Sandia concluded that the foreign materials the Navy found were consistent with the nominal levels found in gun turrets and a salt water environment. For example, calcium and chlorine—two constituents of the Navy's postulated detonator—were readily detectable in turrets on the Iowa, the New Jersey, and the Wisconsin.

While it agreed with the Navy that the powder was chemically stable and confirmed that a significant overram of the powder charge had occurred, Sandia identified a plausible alternative explanation of the cause of the explosion. It believed the forces generated by overramming the powder charge against the base of the projectile can fracture pellets in the bags' top layer releasing burning particles that may ignite the black powder in the adjacent powder bag and, in turn, ignite the whole charge. Sandia believed that the probability of this process occurring depends on the speed of the overram and the number of pellets in the top layer.

## Powder Stability/ Ammunition Problems

GAO found no indications of any chemical stability problems or other problems with the specific type of propellant involved in the explosion.

## Serviceability and Safety

The battleships' equipment failure reports disclosed no systemic material problems with the ships in general or the guns. When compared to similar data on other types of Navy ships, the battleship data indicated that the battleships did not present any undue problems from a maintenance or supply aspect.

The Navy's investigative report noted some safety violations aboard the Iowa. A subsequent investigation by the Navy's Inspector General confirmed that the ship's personnel were conducting improperly approved testing of experimental gunpowder and projectile combinations on the day of the incident and also had done so before. Both reports concluded, however, that these violations did not cause the explosion.

## Manning

The Iowa and the battleships were assigned a disproportionately low percentage of enlisted supervisory personnel, including those responsible for the turrets, when compared to a sample of other ships. Also, GAO corroborated the Iowa's former commanding officer's perception that the quality of manning on the battleships was lower than that for naval ships, on average. For example, battleship personnel were promoted at lower rates and experienced higher disciplinary rates than personnel assigned to a sample of other ships.

## Training

Because training records were destroyed in the explosion, never existed, or have not been located, GAO could not determine if the personnel in turret II were adequately trained. However, it noted that the advanced training school had limited hands-on training aids for instruction on the 16-inch gun turrets and related equipment and that the Navy had not approved a training plan for the battleship gun weapon system.

## Employment

While battleships carry an array of guns and missiles for attacking land targets and surface ships, changing military doctrine and budget constraints limit their utility. Many Navy vessels now carry the same missile systems and thus can attack the same targets. The current maximum range of the battleships' 16-inch guns impairs the ships' ability to provide gun fire support to an "over the horizon" amphibious

assault—one launched from 25 to 50 miles offshore. The battleships also require large crews compared to other ships.

The planned decommissioning of the Iowa and the New Jersey raises questions about the usefulness and supportability of the Missouri and the Wisconsin in the active fleet and makes them candidates for decommissioning. While the Missouri and the Wisconsin have deployed to the Persian Gulf, the battleships' contributions cannot be evaluated because those operations are ongoing.

## Recommendation

GAO recommends that, unless current Middle East operations convincingly demonstrate the unique utility of the battleships to support an amphibious assault, the Secretary of Defense direct the Secretary of Navy to decommission the Missouri and the Wisconsin.

## Agency Comments

The Department of Defense generally concurred with the report's recommendation and its overall contents. The Department said it is "currently reviewing retention of battleships with respect to their capabilities and affordability in view of fiscal and manpower constraints. The results of that review are expected to be reflected in the FY 1992/FY 1993 President's budget." (See app. I.)

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### Abbreviations

| | |
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| BB | battleship |
| DOD | Department of Defense |
| GAO | General Accounting Office |

# Introduction

On the morning of April 19, 1989, five bags of cannon propellant ignited in the open breech of the center gun of the battleship U.S.S. Iowa's turret II as the crew loaded the gun. Forty-seven sailors in the turret died in the blast and ensuing fire. In its investigation of the explosion, the Navy concluded that the explosion was the result of a deliberate act and not a defect in the gun or propellant.

## The Navy's Investigation

The commander of the Atlantic Fleet's surface force, in accordance with the Judge Advocate General Manual, appointed an officer to investigate the facts and circumstances surrounding the explosion, to determine the explosion's cause, and to identify any fault or neglect that pertained to the explosion. Several other officers assisted the investigating officer. A technical support team composed of representatives from a variety of Navy commands and other government activities (such as Headquarters, Naval Sea Systems Command; Naval Ordnance Station Louisville, Kentucky; Naval Ordnance Station, Indian Head, Maryland; Naval Surface Warfare Center, Dahlgren, Virginia; Naval Weapons Support Center, Crane, Indiana; Norfolk Naval Shipyard, Portsmouth, Virginia; and the U.S. Army Ballistic Research Laboratory, Aberdeen Proving Ground, Maryland) also assisted the investigating officer. The Naval Investigative Service also conducted an investigation, and the results of that investigation were included in the Navy's investigation report.

The technical support team initially considered seven possible basic accidental causes for the explosion. These were the effects of friction, flame, compression, impact, electrostatic discharge, electromagnetic radiation, and the characteristics of the ammunition. The team later expanded its scope to include the possibility that a deliberate act caused the explosion.

In mid-July 1989, the investigating officer submitted his report which was endorsed by the Chief of Naval Operations and released to the public in September 1989. The following are the report's significant conclusions.

- None of the three guns in turret II had fired any rounds that morning.
- The crew of the center gun was having a problem.
- An improper propellant/projectile combination and an inappropriate number of powder bags had been loaded into the gun.
- The propellant charge had been rammed 21 inches too far into the gun's chamber.
- The explosion started between the first two propellant bags.

- The explosion forced the projectile more than 3 feet into the barrel where it became lodged.
- Most personnel manning the turret were not properly qualified to perform their assigned tasks.
- A defect in the gun or propellant had not caused the explosion.
- A deliberate act by one of the crew members killed in the explosion most probably caused the explosion.

The conclusion that a deliberate act caused the explosion was based on information developed by the technical support team and the Naval Investigative Service. On the basis of a psychological analysis prepared by the Federal Bureau of Investigation, the Naval Investigative Service concluded that the gun captain[1] of the center gun was the type of person capable not only of committing such an act but also of constructing an explosive device that could have started the explosion. In its examination of the rotating band[2] of the projectile removed from the gun barrel after the explosion, the technical team initially found material foreign to the gun chamber that indicated a timer-controlled explosive device in the gun chamber was the source of ignition.

The technical team continued its work after the investigation report was released to the public and concluded in its final report, dated October 27, 1989, that an electronic device had not been in the gun chamber. A Federal Bureau of Investigation laboratory that examined the rotating band also could not identify evidence of such a device. Rather, the team concluded that foreign material found on the band most closely matched that which an improvised chemical device composed of calcium hypochlorite, brake fluid, and steel wool would produce and that such a device could have ignited the powder.

## Prior Turret Powder Incidents

While its cause appears to be unique, the explosion aboard the Iowa was not the first involving powder fires in turrets to occur aboard U.S. battleships. Six other powder explosions that resulted in fatalities have occurred in battleship turrets since the turn of the century. The most severe occurred aboard the U.S.S. Mississippi in 1924 and 1943 causing

[1]In a 16-inch turret, the three gun captains (petty officers 2nd class or pay grade E-5) are each directly responsible for operating one of the 16-inch guns. Each directly supervises the work of three other crew members. The gun captain's duty position is next to a gun's breech.

[2]The rotating band is a metal ring, predominately copper, that encircles the base of a projectile. Its purpose is to engage the rifling in a gun tube so that the projectile rotates when fired.

47 and 43 fatalities, respectively. The others occurred before World War I.

The Navy's investigations of both Mississippi turret fires concluded that the explosions were caused by conditions resulting from the guns' previous firings. Powder charges being loaded into the guns were ignited either by combustible gasses or burning embers that remained in the gun barrels from previous firings. The Navy concluded that neither of the two conditions could have caused the Iowa explosion since the gun had not been fired that day.

Two of the other explosions were caused by conditions similar to those of the Mississippi, another was caused when a loaded gun fired as the breech was being opened, and the remaining one was caused by molten metal, which resulted from an electrical short, dropping on a powder bag. The Navy concluded that the Iowa explosion was not caused by any of these conditions.

## The Iowa Class Battleships

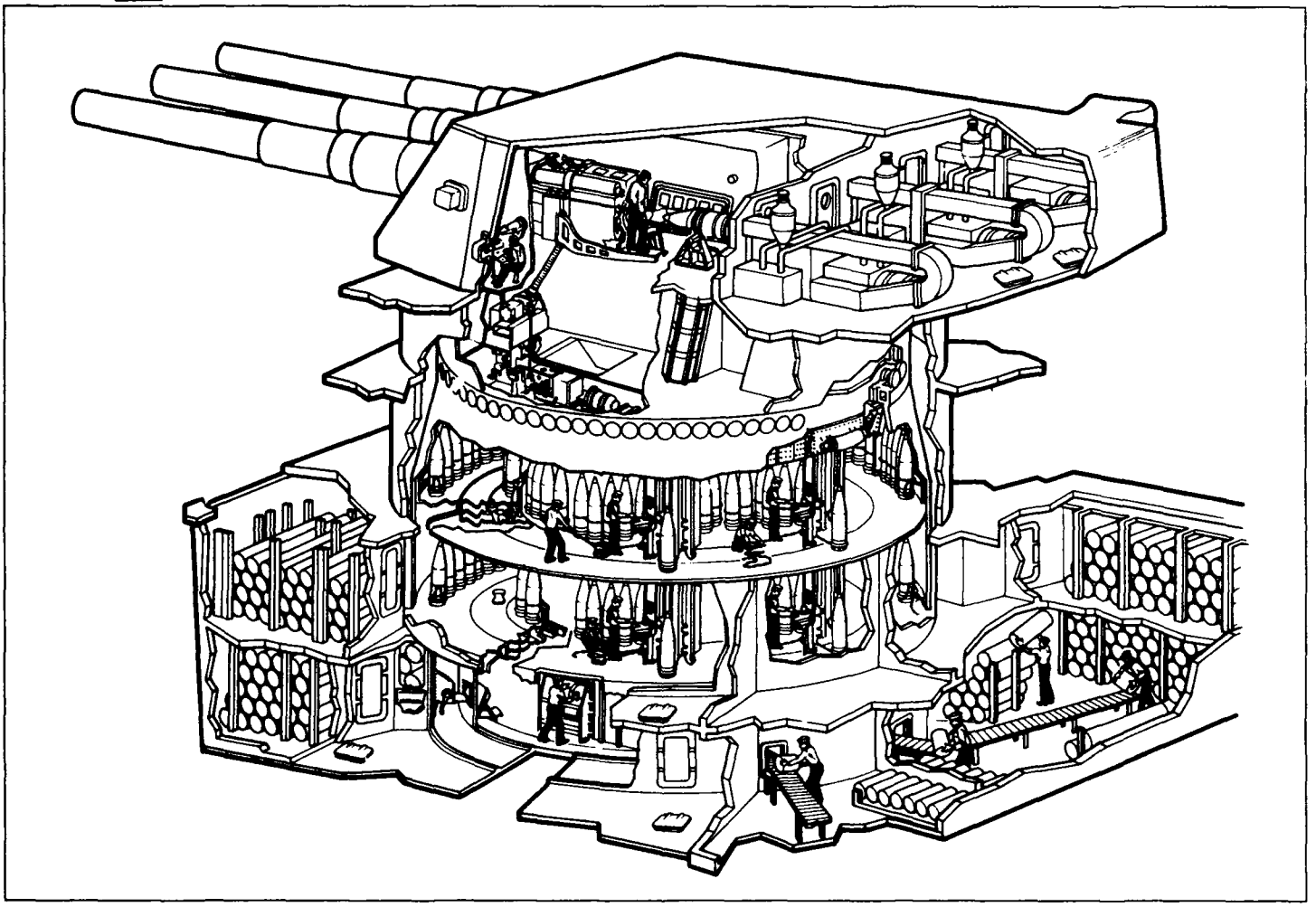
The ships of the Iowa class were the last battleships built by the United States. In addition to the U.S.S. Iowa (BB-61), the class includes the U.S.S. New Jersey (BB-62), the U.S.S. Missouri (BB-63), and the U.S.S. Wisconsin (BB-64). The ships were originally commissioned between 1943 and 1944, were in active status during both World War II and the Korean conflict, and were decommissioned by 1958. Except for the New Jersey's short recommissioning during the Vietnam conflict, no battleships were in active status for almost a quarter of a century until the New Jersey, the first of the four to be reactivated, was recommissioned in December 1982.

**Figure 1.1: U.S.S. Iowa**

Source: U.S. Navy

The ships' principal armament, as built, was a main battery of nine 16-inch guns. Three guns are mounted, as illustrated in figure 1.2, in each of the three turrets. The guns, using several types of powder, fire a variety of projectiles that weigh up to 2,700 pounds and that have ranges in excess of 23 miles. The ships also originally carried 20 5-inch guns, which have a range of about 10 miles, in 10 gun mounts, two guns each. However, upon reactivation, four of these mounts were removed from each ship.

**Figure 1.2: Iowa Class Battleship 16-Inch Gun Turret**



Source: U.S. Navy

The powder for the 16-inch guns is contained in silk bags. Six bags are the standard charge to fire a projectile. Each bag of the type of powder involved in the Iowa explosion contained about 94 pounds of propellant pellets. As shown in figure 1.3, these pellets are stacked vertically in the bag in eight layers. Each bag also contains a trim layer that consists of a variable number of propellant pellets placed horizontally on the top layer of vertically stacked pellets when necessary to standardize the weight of the charge. Additionally, a pad containing black powder is sewn to the base of the bag.

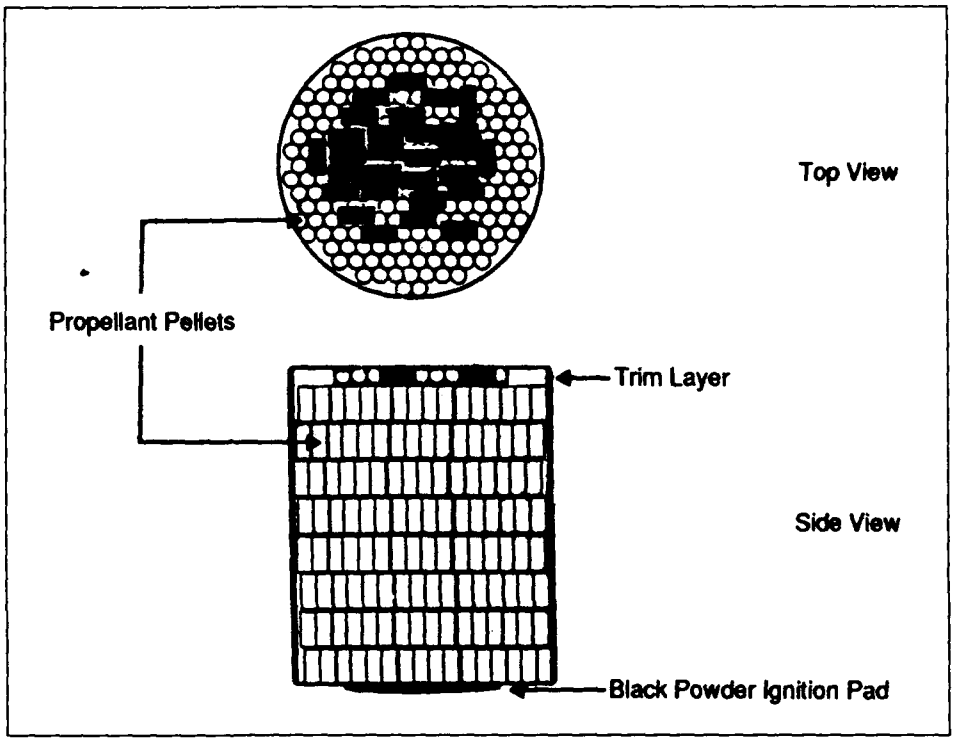


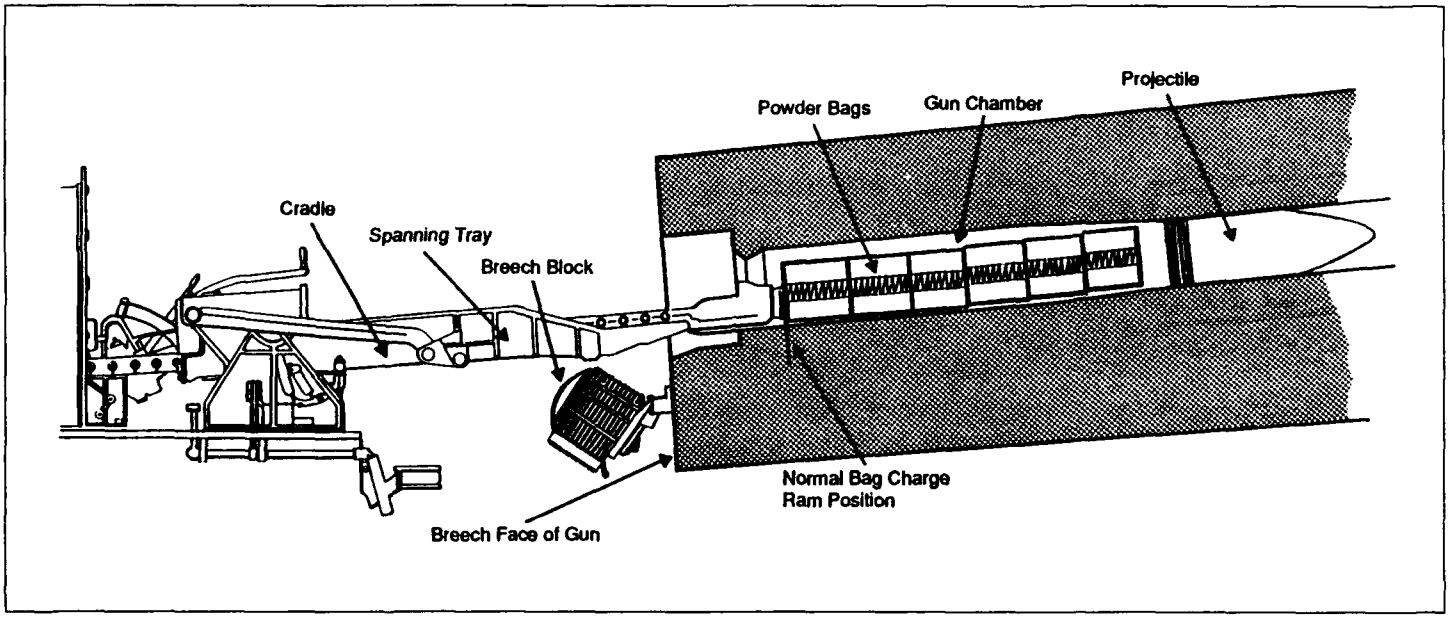

**Figure 1.3: Powder Configuration of the Type of Powder Involved in the Iowa Explosion**

Source: Sandia National Laboratories

The powder bags are transported and stored in metal containers—three bags per container. The bags are removed from the containers prior to firing and are loaded into a gun separately from the projectiles.

Both the projectiles and the powder are loaded into the 16-inch guns using an electric-hydraulic rammer mechanism (see fig. 1.4). The projectile is loaded first, after which the powder bags are loaded. A crew member, responding to hand signals from the gun captain, controls the speed and length of the ram with a manually operated lever. Projectiles are to be rammed at a speed of about 14 feet a second, while the powder charge is to be rammed at about 1 to 2 feet a second. When a gun is fired, the black powder of the bag closest to the breech block is ignited by the primer, which ignites the propellant.

**Figure 1.4: Gun and Rammer**




In addition to the 16- and 5-inch guns, the ships are now equipped to carry 32 Tomahawk cruise missiles and 16 Harpoon missiles. Each ship also is now equipped with four Close-In Weapons Systems and the AN/SLQ-32 Electronic Countermeasures equipment for self-defense.

The ships are heavily armored with as much as 17 inches of steel armor plate protecting the ships' vital spaces. Because of the armor, the Navy considers the battleships to be the most survivable ships afloat.

## The Reactivation Program

In the early 1980s, the Navy viewed reactivation of the battleships as a quick, near-term relief for force structure shortfalls using existing ships. The Navy envisioned that the ships' missions would include operating either as part of an aircraft carrier battlegroup or as the principal ship of a battlegroup composed of surface combatants. One of the principal missions for the battleships was to provide naval gunfire support for amphibious assaults. The Navy requested initial funding to reactivate the Iowa and the New Jersey in the fiscal year 1981 budget. Funding to reactivate the other two battleships was requested in later budgets.

The ships were recommissioned over a 6-year period. The New Jersey was first because it needed less work due to its reactivation during the Vietnam conflict. The dates the ships were recommissioned were

December 28, 1982, for the New Jersey; April 28, 1984, for the Iowa; May 10, 1986, for the Missouri; and October 22, 1988, for the Wisconsin. According to Navy officials, the cost of the reactivations averaged about $435 million per ship.

Because of budget constraints, the Secretary of Defense directed that the Navy decommission two battleships during fiscal year 1991. The Navy selected the Iowa and the New Jersey for decommissioning.

## Objectives, Scope, and Methodology

At the requests of (1) the Chairman, Senate Committee on Armed Services; (2) the Chair, Subcommittee on Economic Stabilization, House Committee on Banking, Finance and Urban Affairs; and (3) Senator Howard Metzenbaum; we assessed several issues concerning the explosion aboard the Iowa and the overall battleship program. Our objectives were to determine the (1) adequacy and validity of the Navy's technical investigation into the possible causes of the explosion; (2) serviceability, supportability, and safety of the battleships' 16-inch guns and ammunition; and (3) adequacy of the battleships' manning and training of assigned personnel. They also asked us to address the authorization for the gunnery experiments that were being conducted on board the Iowa and the battleship employment plan.

Because of the technical complexity of the Navy's tests, we asked the Department of Energy's Sandia National Laboratories to conduct a technical analysis and review the adequacy of the Navy's technical investigation. We selected Sandia at the suggestions of the National Science Foundation and the Office of Technology Assessment. Both stated that the Department of Energy's laboratories, especially Sandia, were sources capable of conducting an independent analysis. We specifically asked Sandia to

- examine the rotating band and the projectile removed from the Iowa's gun for evidence that a detonating device had caused the explosion,
- test the propellant and black powder to ascertain its chemical stability, and
- review the scope and methodology of the Navy's technical investigation.

To determine the serviceability, supportability, and safety of the guns and ammunition, we reviewed reports of equipment failures to determine if the battleships had experienced any unusual serviceability or supportability problems. We examined records of ammunition mishaps and investigations, as well as records pertaining to other ammunition-

related programs, to determine if there had been any previous problems with 16-inch gun ammunition indicative of the Iowa explosion. We also reviewed and analyzed applicable policies, procedures, and other statistical data and pertinent documents.

We addressed the authorization for the gunnery experiments that were being conducted on board the Iowa by reviewing the report of the Navy Inspector General's investigation into the variations and experimentation associated the 16-inch guns.

In addition, we interviewed Navy and Marine Corps officials at various headquarters and operating activities and aboard three of the four battleships as well as crew members aboard two of the battleships. We observed shipboard operations at sea, including firing of the 16-inch guns, aboard the Iowa in November 1989 while the ship was deployed to the Mediterranean Sea.

To determine if manning levels were comparable and if assigned personnel were comparable in terms of general aptitude, performance, and behavior, we compared information on the personnel assigned to the battleships to information on the personnel assigned to a sample of 17 other surface warfare ships. To provide comparisons that were as valid as possible, we selected, after discussing our criteria with Navy officials, surface ships that

- are the responsibility of the Deputy Chief of Naval Operations for Surface Warfare (i.e., oversight and funding decisions),
- are nonnuclear powered,
- have weapon systems similar as possible to those on the battleships,
- are homeported in the United States,
- are not serving in a special role such as a fleet flagship,
- provided a balanced mix of Atlantic and Pacific Fleet ships, and
- had deployed in fiscal year 1987 through the first quarter of fiscal year 1990 time frame.

We selected the following ships for our sample.

- Battleships
  - U.S.S. Iowa
  - U.S.S. New Jersey
  - U.S.S. Missouri
  - U.S.S. Wisconsin

- Cruisers
  - U.S.S. Josephus Daniels
  - U.S.S. Wainwright
  - U.S.S. William H. Standley
  - U.S.S. Fox
  - U.S.S. Biddle
- Destroyers
  - U.S.S. Spruance
  - U.S.S. Paul F. Foster
  - U.S.S. Compte de Grasse
  - U.S.S. Merrill
  - U.S.S. Conolly
  - U.S.S. John Rodgers
  - U.S.S. Leftwich
  - U.S.S. Deyo
  - U.S.S. Ingersoll
- Amphibious Assault Ships
  - U.S.S. Tarawa
  - U.S.S. Nassau
  - U.S.S. Peleliu

To determine if the battleships' manning levels were comparable to those of the ships sampled, we compared the strengths at three points in time — a point approximately 5 months before ships' deployment, the deployment months, and the months the ships returned from deployment. At each point, we compared the battleships' manning levels for overall enlisted personnel, gunner's mates, and fire controlmen to the battleships' current wartime, peacetime budgeted, and peacetime authorizations against the composite of the same factor for the sample ships. In making the comparisons, we grouped personnel as supervisors (E-7s through E-9s), journeymen (E-5s through E-6s), and apprentices (E-1s through E-4s) — groupings used within the Navy personnel management process. We did not include the Wisconsin in the manning level comparisons since, at the time of our review, this battleship had not been deployed since its reactivation.

To compare general aptitude, performance, and behavior, we selected and reviewed, again with Navy officials' concurrence, seven enlisted personnel and one officer-related profile factors. The enlisted personnel profile factors included Armed Forces Qualification Test scores and performance evaluation averages for the crew members assigned as of late October 1989; enlisted personnel promotion results from the March 1989 test cycle, considering gunner's mates and fire controlmen for promotion to grades E-4 through E-6; fiscal year 1989 urinalysis results as reported by the Navy drug screening laboratories; and nonjudicial punishments, courts-martial, and punitive discharges reported during fiscal year 1989 by the individual ships and the Navy's Office of the Judge Advocate General. The officer-related profile factors were selection rates for department head, executive officer, and commanding officer positions. We did not make promotion rate comparisons since few officers aboard the battleships and the sample ships were eligible for promotion.

We reviewed internal ship records and interviewed personnel on board the Iowa and the New Jersey to assess the adequacy of on-the-job training programs designed to supplement the Navy's formal 16-inch gun training programs. We also visited the Navy's school that teaches the advanced training courses related to 16-inch gunnery, fire control, and turret officers' duties. Additionally, we reviewed external inspection results of the Iowa's weapon system training programs for about 18 months preceding the April 1989 explosion to determine if those reports identified any training problems relating to the 16-inch guns.

We discussed the battleships' peacetime and wartime roles with Navy and Marine Corps officials. We also reviewed pertinent documents such as policy documents concerning the battleships' use and the employment schedules for the battleships.

We made our review at various headquarters and operating activities (see app. II). Our review was made in accordance with generally accepted government auditing standards and was performed between October 1989 and August 1990. However, Sandia has continued to pursue the technical investigation. This report, therefore, does not reflect its final conclusions.

# Chemical and Impact Sensitivity Issues

Sandia National Laboratories could neither confirm nor deny the Navy's conclusion that a deliberate act of a crew member caused the Iowa explosion, nor could it prove or disprove the Navy's contention that foreign material on the rotating band was evidence of an improvised explosive device used to ignite the powder charge. Instead, Sandia identified what it believed to be a plausible alternative explanation for the explosion stemming from its studies of the effects of impact forces on the propellant grains. It did agree with the Navy's conclusion that the powder charge had been overrammed and with several other conclusions concerning the stability of the black powder and the propellant pellets and their susceptibility to accidental ignition. Sandia, however, noted in its report[1] prepared for us that its study was not complete in that it had not identified a clear and definite cause of the explosion, and it recommended that the Navy investigate the explosion further.

## Chemical Detonator Not Corroborated

On the basis of its tests and analyses and its review of the Navy's work concerning foreign material on the rotating band of the projectile lodged in the Iowa's gun after the explosion, Sandia concluded that the available data were insufficient to prove or disprove the presence of a chemical device that may have ignited the powder charge and caused the explosion. Sandia noted that its analyses were constrained by the condition of the Iowa's rotating band samples it obtained from the Navy. An untested portion of the band was not available to Sandia. After the Navy's and the Federal Bureau of Investigation's analyses, all portions of the band had been subjected to varying degrees of previous analyses or examination. However, Sandia was able to incorporate the results of the Navy's analytical work with its own analyses of the samples it was provided in reaching its conclusions.

Sandia disagreed with the Navy's contention that the presence of iron fibers with high concentrations of the elements calcium and chlorine and chemical compounds such as various glycols and a polymer compound on the rotating band indicated a chemical ignitor device had been in the gun chamber. Sandia concluded that the concentrations of these two elements, which it found and the Navy generally found, were consistent with nominal calcium and chlorine levels on metal fibers found elsewhere in the turrets and were also consistent with an environment exposed to salt water and salt spray. Sandia found that both elements were readily detectable throughout turrets I and II on the Iowa and also in turrets on the New Jersey and the Wisconsin. Sandia considered the

[1] Review of the USS Iowa Incident (SAND90-1158, dated 06-90).

one iron fiber the Navy found with high concentrations of calcium, and on which the Navy based its conclusion of a chemical device, to be atypical of all the fibers the Navy examined.

Sandia also questioned the Navy's findings of glycols. The Navy identified the glycols as components of brake fluid that would have been part of a chemical ignitor device. Sandia noted that the compounds were also constituents of the cleaning and lubricating fluid routinely used within the turrets and that the fluid was also used during the process of removing the lodged projectile from the gun after the explosion.

Sandia could not confirm the identity of the polymer substance or the iron fibers that the Navy found on the band. The Navy concluded that the polymer was a remnant of a plastic bag containing an improvised chemical ignitor device and that the fibers were steel wool—another component of such a device. Although Sandia could not link the polymer to a plastic bag, it noted that several polymers were present in the turrets and noted possible alternate sources such as the bore brush used to clean the gun. It agreed that iron fibers were present on the band, but it could not conclude that steel wool was the source of those fibers.

## Powder Was Overrammed

Sandia agreed with the Navy's investigation report that the powder charge was rammed too far into the gun's chamber but disagreed as to the distance of the overram. It also disagreed with the report concerning the speed of the rammer mechanism.

While the Navy's report stated the powder had only been rammed about 21 inches too far, Sandia concluded from its analysis of the damage the rammer chain caused as the chain was blown out of the chamber that the powder had been rammed about 24 inches too far. According to Sandia's analysis, the longer overram compressed the powder charge against the base of the projectile before it ignited.

The Navy based its estimate that the rammer mechanism had been operating at a rate of about 1 foot a second when the overram occurred on the post explosion position of the mechanism that controls the rammer. While Sandia could conclusively state only that the rammer's speed was at least 2 feet a second, an analysis indicated the speed could have been about 6.5 feet a second. Sandia pointed out that the force of the blast and the resulting debris could have changed the control mechanism's position and that the higher speed would have provided the force to

compress the powder charge to the extent suggested by a 24-inch overram.

Additionally, Sandia noted that the car that brings the powder to the gun room had not returned to the turret's lower levels, which it normally would have during the time of a normal speed ram. Sandia believes this could be indicative of a higher rammer speed because if the powder had been rammed at the normal speed and then held compressed against the base of the projectile for 15 to 20 seconds as the Navy postulated, the car should have begun its return. We believe another suggestion of a high-speed overram comes from the Navy's investigation report, which noted that the rammerman was conducting his first live firing and that reports of an unidentified problem with the center gun were made immediately before the explosion.

## Sensitivity to Impact Forces

Sandia offered an alternative to the Navy's conclusion that impact and compression of the bag charge resulting from the overram were not contributing factors to the Iowa explosion. Sandia believes a high-speed overram of the powder bags, combined with the impact sensitivity of the powder, could have caused the explosion.

Sandia based its conclusions on the results of experiments using small-scale devices (the largest was 8 inches in diameter) to replicate pressures on pellets. Sandia found powder ignition can occur when powder bags containing a reduced number of propellant pellets in the trim layer are subjected to the impact forces of a high speed overram. Under these conditions, some of the pellets in the trim layer can fracture, which may release burning particles that can ignite the black powder in the adjacent powder bag, which, in turn, ignites the whole charge.

Sandia believed that the speed of the overram and the number of pellets in the trim layer can affect the probability of this sequence of events. The probability increases as the speed increases and the number of pellets decreases.

Sandia believed that ignition could occur in 16-inch diameter devices at forces that correspond to those generated by the gun's rammer system. However, it noted that its results were obtained by using less than full-scale laboratory devices and that the forces acting on a powder charge overrammed in a 16-inch gun could be quite different.

## Areas of Agreement

In addition to agreeing that the powder charge had been overrammed, Sandia agreed with or confirmed several conclusions of the Navy's technical analysis. Sandia agreed, for example, that the interface of the two bags adjacent to the base of the projectile was the most probable location of ignition. It also generally agreed that (1) propellant chemical stabilizer levels were within acceptable and prescribed limits, (2) mechanical operations in the gun room appeared normal, and (3) electrostatic discharge effects, electromagnetic radiation effects, friction, and thermal effects were unlikely causes of the explosion. Sandia also concluded that the ether vapors released by the propellant, if ignited, could not produce sufficient heat to ignite the propellant.

## Sandia's Recommendations

Sandia made three recommendations in its report. First, it recommended that the 16-inch guns be equipped with a mechanism to control the speed of the rammer and the placement of the powder bags. Second, it recommended that the powder bag be redesigned to eliminate the need for a trim layer to reduce the propellant's sensitivity to impact. Third, it recommended that further testing be conducted to fully define the safe limits of pellet configuration, bag compression, rammer speed, and other relevant 16-inch gun and turret operations.

## Navy's Response

When it became aware of Sandia's conclusions, the Navy began a series of tests of the effects of impact forces on full-size powder charges. After a powder ignition occurred during those tests, the Navy suspended 16-inch gun firing aboard all four battleships and reopened its investigation on which Sandia is working with the Navy.[2] In addition, the Navy is also exploring safety modifications to the 16-inch gun weapon system because of Sandia's conclusion that an overram of the powder may have caused the explosion.

## Agency Comments and Our Evaluation

The Department of Defense (DOD) said that both the Navy and Sandia are continuing their investigation of the cause of the explosion and discussed the Navy's actions to ensure the safe use of the 16-inch gun system. DOD's comments compliment our original discussion.

[2]On the basis of the results of its additional testing, and because of the Wisconsin's role in Operation Desert Shield, the Navy lifted the firing suspension for the Wisconsin in September 1990.

# Safety and Serviceability Considerations

On the basis of the battleships' reported equipment problems, ammunition mishap and malfunction reports, and personnel-related injury data, we found no evidence of any systemic or unusual serviceability or safety problems aboard the battleships. However, the Navy's investigation of the U.S.S. Iowa explosion did find some safety violations aboard the Iowa at the time of the explosion. Also, a later Navy Inspector General's investigation confirmed that an improperly approved experimentation of gunpowder and projectile combinations was being conducted.

## Powder Stability/ Ammunition Problems

Neither our analysis of ammunition reports and other reports nor Sandia's laboratory tests of Iowa powder samples indicate that chemically unstable powder was a likely cause of the explosion. Sandia tested the propellant to determine its chemical stability, and on the basis of those tests, it concluded that stabilizer levels were adequate and met specifications.

We examined several data sources, including ammunition mishap and malfunction reports and investigations, to identify any serious, systemic ammunition problems and found no indications of problems with the specific type of propellant involved in the explosion. However, ammunition problems have been encountered with 16-inch ammunition components in the past. For example, some propellant bags of other types of 16-inch propellant split, allowing the pellets to spill out. A program is underway to correct that problem by manufacturing bags of a different material. However, this problem was never reported for the type of propellant involved in the Iowa explosion.

Other problems were encountered in the primers used to ignite the powder charges. The primers, when removed from their shipping containers, deteriorated in storage and were not reliably igniting the powder charges. The deterioration is being addressed through a product improvement program. However, as the Navy's investigation report concluded, the primer was not a factor in the Iowa explosion.

While 16-inch ammunition components are sensitive to unplanned heat, blast, or impact stimuli such as those that could be caused by battle damage, the current 16-inch gun ammunition inventory ranks 19th among the munitions of greatest safety concern to the Navy. However, the Navy has waived the requirement for the current inventory to meet the standards for insensitivity to those stimuli. It believes that this inventory poses a relatively lower danger than that posed by other ship board munitions that were ranked higher. The Navy, therefore,

accorded a higher funding priority to modifying the other munitions (emphasis is given to the 15 munitions of greatest concern). According to the Navy, new development items will meet the standards.

Concerns were raised after the explosion over the ammunition's sensitivity to the effects of electromagnetic radiation. Communications and radar transmitters can transmit electromagnetic radiation that can cause ammunition components containing electrical circuits to detonate. On April 19, 1989, the primer was the only ammunition component that contained an electrical circuit, and it required only moderate protection from electromagnetic energy. For example, it could not be within 56 feet of a transmitting AN/WSC-3 communications antenna. Turret II was about 100 feet from that type of antenna at the time of the explosion. In its investigation, the Navy ruled out the primer as the cause of the explosion.

## Equipment Serviceability

We found no evidence of systemic mechanical or supply support problems with the 16-inch guns or the battleships in general. In making that determination, we compared data from maintenance reports for all four battleships since their reactivation with similar data for other Navy surface combatants, such as cruisers, destroyers, and frigates. This comparison indicated that the battleships had not experienced material problems different from those experienced by other naval ships.

Equipment failures that cannot be corrected within 48 hours and that affect a ship's ability to perform its mission are to be reported to operational commanders and support activities. The reports, which are called Casualty Reports or CASREPS, identify the specific equipment problem and the reason that completing repairs is delayed. Repairs may be delayed, for example, because parts are not available aboard ship or because a ship's crew needs technical assistance to complete the repairs.

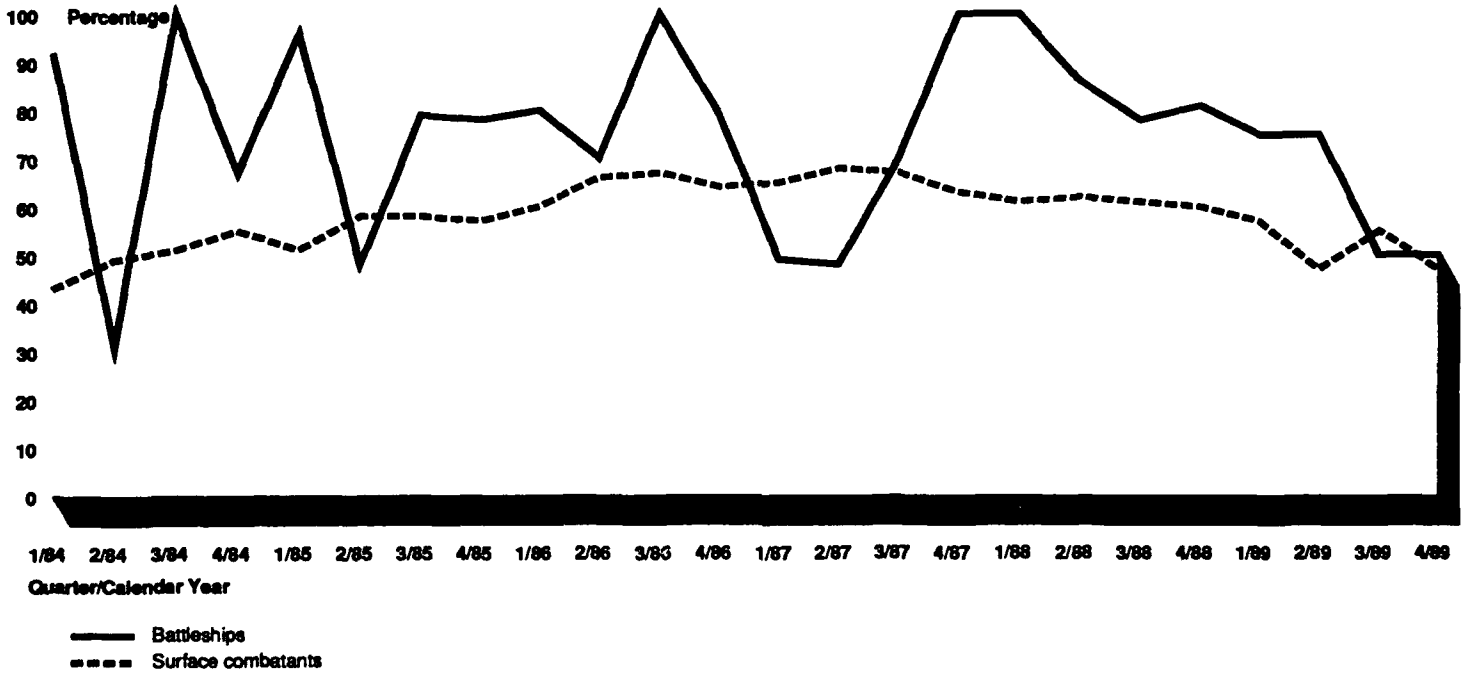
Reported failures are categorized according to the failures' affect on a ship's ability to perform its missions. Equipment failures are categorized as having a minor or a major impact on a ship's primary mission or as signifying that primary warfare tasks cannot be performed.

All of the equipment failures the battleships reported as affecting the 16-inch turrets from the ships' reactivation until March 1990 were categorized as having only a minor impact on the ships' primary mission. The reported failures affected a variety of the electrical and mechanical

systems within the turrets. In addition, the numbers, types, and frequencies of reported equipment failures varied among the four battleships.

For a broader comparison, we compared the battleships' overall equipment readiness to that of other Navy surface combatants to determine if the battleships, as a group of ships, present any undue material or supply support problems. As figure 3.1 shows, between 1984 and 1989 the battleships operated without any failures that had a major impact on or precluded the ships from performing a primary mission for a substantially greater percentage of time than did surface combatants as a whole. The battleships had the better record in this regard for 19 of the 24 quarters in this period. Additionally, the battleships reported no failures of this severity during four quarters. During the period covered by the comparison, the number of battleships in commission increased from one to four while the total number of surface combatants ranged from about 180 to about 200. The battleships' experience showed more variation than did the surface combatants because of the small number of battleships in commission.

**Figure 3.1: Operating Time Free of Serious Equipment Failures**




Source: U.S. Navy

There were no distinct overall differences between the battleships and the surface ships in the proportion of the total number of equipment failures due to the unavailability of repair parts, about 62 percent of the total failures in each case. However, only about 3 percent of the battleships' total supply-related failures had a major impact on or precluded the ships from performing a primary mission while about 11 percent of the supply-related failures for all surface ships were so categorized.

On the basis of its visits to the Iowa, Sandia found that the powder hoist, powder door, rammer, and other equipment in the gun room appeared to have been in proper operating condition at the time of the explosion. It therefore concurred with the Navy's conclusion that mechanical operations were not associated with the explosion.

We discussed turret serviceability with Iowa crew members who said they were not aware of any unusual problems in the turrets that they thought could have been related to the explosion.

## System Safety

Our review of battleship injury reports revealed no prior safety problems with the 16-inch gun system. However, the Navy's investigation of the explosion found some safety violations aboard the Iowa at the time of the explosion. A subsequent investigation by the Navy Inspector General also confirmed that improperly approved experimentation of gunpowder and projectile combinations was being conducted on the day of the explosion and that similar experimentation without proper authorization had also been conducted before.

## Personal Injuries

Any accident resulting in a fatality, a lost workday, an electrical shock, a person overboard, or a chemical or toxic exposure must be reported to the Navy Safety Center. We reviewed the reports of personal injuries and deaths that had occurred on board the battleships since their recommissioning through December 1989 and compared the results to injury rates for all surface ships to determine if this would reveal any systemic gun or ammunition problems.

None of the reported accidents for the battleships indicated a systemic problem with the 16-inch guns. Other than the Iowa's turret explosion, none involved firing the 16-inch guns. One sailor, however, was injured in a turret during a training drill, and another was injured in a 16-inch magazine while conducting an operational test.

The majority of the accidents aboard the battleships (about 64 percent) occurred during routine upkeep or steaming activities. Other accidents occurred while the ships were being overhauled or while the crew members were firing the guns or handling cargo or ammunition. For example, sailors slipped and fell on decks and ladders, had hatches closed on their hands, or were injured handling heavy equipment or supplies.

Most of the injuries involved fractures, inhalation of toxic fumes, contusions, poisoning, and lacerations that were incurred during routine operations. In addition, while some of the reported accidents involved electrical shocks, none were reported to have occurred in the 16-inch turrets.

We found, based on Navy data, that the injury rates for the battleships were lower than the rates of injuries for surface ships in 1987 and 1988. The battleships' 1989 rate would have been lower if the Iowa explosion had been excluded from the data. While the Iowa had the highest injury rate of the four battleships in 1989 (as a result of the turret explosion),

its injury rate was not the highest among the battleships in 1987 and 1988.

## Safety Violations

According to the Navy's investigation report, approved procedures to ensure the safe firing of the 16-inch guns were not followed aboard the Iowa on April 19, 1989. The report stated that cigarette lighters and keys were found on the remains of the deceased sailors even though flame-, heat-, or spark-producing devices are prohibited in the turrets.

The Navy's report also stated that Iowa personnel had improperly approved 16-inch gunnery experiments and were conducting them at the time of the explosion. Crew members were loading an inappropriate projectile/powder combination when the explosion occurred. This involved five bags of an unauthorized type of powder with a 2,700-pound projectile rather than six bags of the authorized type of powder. Ship personnel had no authority to approve or fire such a combination. Improperly authorized combinations were fired on at least two other occasions. However, the Navy's investigation concluded that neither the presence of items found on the deceased sailors nor the experimental firing caused the explosion.

At the Chief of Naval Operations' direction, the Navy Inspector General later investigated the reported experimentation and concluded that the firings in question should not have been authorized and were contrary to Navy procedures. The Inspector General report also noted instances in which Naval Sea Systems Command activities had developed, funded, and tested 16-inch ammunition components, including new designs of both projectiles and powder charges without proper authorization. That report stated that these actions had resulted from an unauthorized but institutionalized process and that the safety hazard posed to the Iowa's crew by the experiments was, at best, undetermined.

## Agency Comments and Our Evaluation

DOD concurred with our assessment of safety and serviceability.

Chapter 4

# Weaknesses in Battleship Manning and Training

Our review found a number of manning and training problems aboard the Iowa and the other battleships. Our analyses, with particular emphasis on the Iowa, noted supervisory personnel shortages, especially in gunnery related positions in the turrets, lower promotion rates, and higher rates of disciplinary problems for battleship personnel compared to Navy personnel on other ships. We also found training deficiencies, such as the lack of an approved battleship gun weapon system training plan, limited hands-on training aids at advanced 16-inch gunnery schools, and inadequate external oversight of the Iowa's 16-inch gun personal qualifications program.

The adequacy of manning and training of the crew members aboard the Iowa became an issue because the Navy's investigation report stated that unqualified personnel were manning the ship's 16-inch gun turrets the day of the explosion. The ship's former commanding officer disagreed, stating the crew was trained but that the records were not up to date. He also said that the Iowa not only had been assigned too few people in the more senior enlisted grades but that the assigned personnel were of a lower caliber than those assigned to other Navy ships.

We were unable to reconcile the conflict over the crew's training. The training records for the deceased crew were destroyed in the explosion, never existed, or have not been located. Oversight inspections, which should have assessed the Iowa's 16-inch personnel qualification standard program, failed to do so during the 18 months preceding the explosion. In addition, an analysis by the ship's former commanding officer showing that the crew was trained had weaknesses.

Navy officials confirmed that they have had difficulty filling supervisory positions on battleships because of limited career opportunities, and they believe the lack of supervisory personnel may have been a contributing factor to the battleships' higher percentage of disciplinary problems.

## Battleship Manning Problems

Significant shortfalls existed aboard the battleships[1] in overall enlisted supervisory manning, particularly in the two ratings related to gunnery operations—gunner's mates and fire controlmen—when compared to the other ships sampled. Also, at the time of the explosion, key positions in the turrets were filled with lower graded personnel than required.

[1]We did not include the Wisconsin in the manning level comparisons because, at the time of our review, this battleship had not been deployed since its reactivation.

While priority previously given to fill positions for supervisory gunner's mates aboard the ship by personnel assignment activities was proper, the Iowa had significant shortages in its assigned crew at the time of the explosion.

## Battleships Were Not Assigned a Comparable Share of Supervisors and Key Gunnery Personnel

The battleships and the other ships in our sample were authorized comparable portions of their full wartime strength, including gunner's mates and fire controlmen. However, comparable percentages of authorized strengths of enlisted supervisors (E-7 through E-9) or of supervisors and journeymen (E-5 through E-9) in the gunner's mate and fire controlman ratings were not assigned to the battleships. The battleships (including the Iowa) deployed with significantly lower percentages of both their authorized enlisted supervisors and their gunnery related journeymen than the other ships, as shown in table 4.1. These shortages were especially pronounced for gunner's mates and fire controlmen.

**Table 4.1: On-Board Percentages of All Supervisors, Gunner's Mates, and Fire Controlmen Compared to Authorized Levels at Deployment**

Figures in percent

| | Iowa | Battleships | Ship sample |
|---|---|---|---|
| **All supervisors** | 92 | 93 | 101 |
| **Gunner's mates:** | | | |
| Supervisors | 73 | 77 | 100 |
| Journeymen | 88 | 82 | 135 |
| Apprentices | 94 | 92 | 73 |
| **Fire controlmen:** | | | |
| Supervisors | 92 | 88 | 120 |
| Journeymen | 89 | 92 | 128 |
| Apprentices | 106 | 109 | 85 |

Navy personnel officials stated that the ship sample could have had excess gunner's mates and fire controlmen at the journeymen and supervisory levels because of higher promotion rates. Personnel promoted, for example, during a deployment are not reassigned, even though on-board excesses develop. Also, since the school terms for gunner's mates and fire controlmen assigned to the ships in our sample are longer than the school terms for gunner's mates and fire controlmen operating the 16-inch guns, personnel tend to be a higher grade when reporting to the ships in our sample.

These officials acknowledged difficulties in filling journeymen and supervisory level billets on battleships. They said that personnel who

are reenlisting, especially gunner's mates and fire controlmen, generally do not want battleship assignments. According to the officials, these personnel frequently request duty elsewhere to enhance their promotion opportunities by gaining practical experience in the more common gun systems. Similarly, they prefer to attend schools for weapons systems that they believe will enhance their promotion opportunities and their prospects for future civilian employment. They receive training in more modern technologies, such as electronics, at those schools. Sailors aboard the Iowa expressed similar views. Officials responsible for assigning personnel to the ships told us that lower rated personnel are assigned to the battleships to ensure they are staffed to meet the total number required.

## Key Turret Positions Filled With Lower Graded Personnel

At the time of the explosion, key turret positions on the Iowa were filled with lower graded personnel than prescribed in the ship's manning document. In turret II, only the center gun captain position was filled by a journeyman. All three gun captains in turret I were E-4 apprentices, and an E-5 journeyman was filling the supervisory turret captain's position for which the manning document prescribes an E-7.

## Navy Properly Prioritized Iowa's Supervisory Gunners Mate Requisitions

The Iowa's commanding officer raised concerns about the battleships' low priority for assignment of personnel—particularly supervisory gunner's mates. When he assumed command of the ship in May 1988, the ship had recently returned from a deployment and had shortages in supervisory gunner's mates. He was concerned because he believed the ship was ranked number 37 in priority at that time for filling an E-7 supervisory gunner's mate position. The Iowa's 10 requisitions for personnel at that grade at the time were included in a group of 67 Atlantic Fleet requisitions for supervisory gunner's mates. The Iowa's requisitions ranked from 34th to 55th in priority in that group. The 21 highest priority requisitions were for ships scheduled for upcoming deployments. At that time, the Iowa was not scheduled to deploy for about another year. The remaining higher ranked requisitions were for other ships that had a lower percentage of supervisory gunner's mates on board compared to the Iowa.

## Quality of Battleship Personnel Differed From Other Navy Personnel

Battleship personnel rated lower in several job performance and behavioral measures when compared to the ship sample and Navy-wide personnel. For example, battleship personnel were promoted at lower rates, and they experienced more frequent legal and disciplinary problems such as nonjudicial punishments,[2] courts-martial,[3] and punitive discharges[4] during fiscal year 1989. In addition, battleship officers were selected for leadership positions at a lower rate than those that were serving on the sample ships. Conversely, battleship personnel had a lower incidence of drug use and comparable entry level test scores and job performance evaluations.

## Battleship Enlisted Personnel Have a Lower Rate of Promotion

As part of the promotion process, Navy personnel are tested to determine their qualification for promotion. During the March 1989 promotion cycle, enlisted personnel on battleships were selected for promotion less frequently when compared to those serving on ships in our sample and to those eligible personnel Navy-wide. (See table 4.2.)

**Table 4.2: Promotion Rates for E-3 Through E-5 Personnel** (March 1989 Cycle)

Figures in percent

| Assignment | Promotion rates: Gunner's mates | Promotion rates: Fire controlmen |
|---|---|---|
| Iowa | 36 | 4 |
| Battleships | 53 | 8 |
| Ship sample | 65 | 15 |
| Navy-wide | 58 | 13 |

The lower rate of selection may be attributed to the fact that battleship gunner's mates and fire controlmen also scored lower, on the average, and failed promotion tests more often when compared to the respective ship sample and Navy-wide results (see table 4.3). Navy personnel officials said that battleship gunner's mates and fire controlmen fare worse

[2]A nonjudicial punishment is a more serious disciplinary measure than an administrative corrective measure but less serious than trial by court-martial.

[3]A court-martial is a military trial for a service member. The three types—general, special, and summary—differ in their composition, the nature of the offenses brought before them, and the level of punishment they can impose. General courts-martial deal with the most serious offenses and can impose the most severe punishments, while summary courts-martial deal with the least severe offenses.

[4]Punitive discharges are categorized as either bad conduct or dishonorable. Both are severe punishments that could deprive a service member of substantially all military benefits.

on promotion tests because they do not receive daily hands-on experience or get training opportunities on the more common Navy gun systems that are emphasized on the promotion tests.

**Table 4.3: Promotion Test Results for E-3 Through E-5 Personnel** (March 1989 Cycle)

Figures in percent

| Assignment | Average test score (all personnel) | Failure rates | |
|---|---|---|---|
| | | Gunner's mates | Fire controlmen |
| Iowa | 47.77 | 12 | 9 |
| Battleships | 49.07 | 11 | 6 |
| Ship sample | 51.45 | 0 | 1 |
| Navy-wide | unavailable | 10 | 4 |

## Battleship Officers Selected for Leadership Positions at Lower Rates

The officers aboard the battleships who are responsible for the day-to-day warfare operations were selected at a lower rate for leadership positions than were officers in similar positions in the ship sample. We compared the rate at which officers were considered qualified to serve as department heads, executive officers, and commanding officers during fiscal year 1989. These positions constitute the three major levels of responsibility officers progress through while serving aboard ships. We found that battleship officers were selected less frequently in all three categories (see table 4.4).

**Table 4.4: Officer Selection Rates** (Fiscal Year 1989)

Figures in percent

| | Lieutenants: department heads | Lieutenant Commanders: executive officers | Commanders: commanding officers |
|---|---|---|---|
| Iowa | 50 | 25 | 25 |
| Battleships | 54 | 53 | 23 |
| Ship sample | 78 | 56 | 88 |

Navy officials said that battleship officer selection rates may be lower because the officers have often failed to be selected in the past and are thus placed on the battleships to broaden their duties and responsibilities in order to increase their future chances of selection.

DOD also pointed out that the results of the comparisons are influenced, to a degree, by differences in authorized grades among the battleships and the other types of ships in the sample. Commanders on battleships,

for example, serve as department heads, while commanders on many of the sample ships are the commanding officers.

## Battleship Personnel Have More Legal and Disciplinary Problems

During fiscal year 19. battleship personnel experienced a higher rate of disciplinary actions, such as nonjudicial punishments, courts-martial, and punitive discharges, when compared to the ship sample and Navy-wide personnel. For example, the battleships' nonjudicial punishment rate was about 27 percent higher than the ship sample rate and 183 percent higher than the Navy-wide rate. (See table 4.5 for specific rates.) However, gunner's mates and fire controlmen received about 4 percent of the battleships' nonjudicial punishments and 2 percent of the ship sample's nonjudicial punishments while comprising about 15 and 7 percent, respectively, of the personnel on those ships.

**Table 4.5: Nonjudicial Punishment Results**

| | Average monthly manning | Number of nonjudicial punishments | Rate per 1,000 |
|---|---|---|---|
| Iowa | 1,322 | 230 | 174 |
| Battleships | 5,273 | 1,030 | 195 |
| Ship sample | 7,319 | 1,128 | 154 |
| Navy-wide | 606,910 | 41,855 | 69 |

The battleships' court-martial rate per thousand was nearly 120 percent higher than the ship sample rate and about 165 percent higher than the Navy-wide rate. The Iowa's rate was over three times that of the Navy-wide rate. Gunner's mates and fire controlmen, who constitute over 20 percent of battleship personnel, received 2.5 percent of both the battleships' and the ship sample's court-martials. The specific number of courts-martial and the rates are shown in table 4.6.

**Table 4.6: Court-Martial Results** (Fiscal Year 1989)

| | Average monthly manning | Number of courts-martial | | | | Rate per 1,000 |
|---|---|---|---|---|---|---|
| | | General courts | Special courts | Summary courts | Total | |
| Iowa | 1,322 | 1 | 23 | 16 | 40 | 30 |
| Battleships | 5,273 | 11 | 65 | 48 | 124 | 24 |
| Ship sample | 7,319 | 6 | 71 | 2 | 79 | 11 |
| Navy-wide | 606,910 | 588 | 3,341 | 1,679 | 5,608 | 9 |

The battleships' punitive discharge rate also was significantly higher than the ship sample and Navy-wide rates. As shown in table 4.7, the

battleships' punitive discharge rate during fiscal year 1989 was at least twice that of the ship sample and Navy-wide rates. About 2 percent of the battleships' gunner's mates and fire controlmen and about 3 percent of the sampled ship's gunner's mates and fire controlmen received punitive discharges.

**Table 4.7: Punitive Discharges** (Fiscal Year 1989)

| | Average monthly manning | Number of punitive discharges | | | Rate per 1,000 |
|---|---|---|---|---|---|
| | | Bad conduct | Dishonorable | Total | |
| Iowa | 1,322 | 12 | 0 | 12 | 9 |
| Battleships | 5,273 | 52 | 1 | 53 | 10 |
| Ship sample | 7,319 | 38 | 2 | 40 | 5 |
| Navy-wide | 606,910 | 2,270 | 212 | 2,482 | 4 |

Navy officials said that the large number of lower ranking personnel and the corresponding shortage of supervisors were the primary causes for these higher rates of disciplinary problems on battleships. For example, E-1s through E-4s—the group that received over 90 percent of the nonjudicial punishments and over 95 percent of the courts-martial and punitive discharges—constituted more than 70 percent of battleship manning.

## Entry Level Test Scores and Performance Evaluations Were Similar

Battleship personnel compared favorably to the sample ship and Navy-wide personnel on at least two measures:

- the Armed Forces Qualification Test, which is an entry level test measuring an individual's verbal and mathematical knowledge, and
- performance evaluations, which are prepared annually to measure performance in several areas such as military knowledge, personal behavior, and leadership ability.

The average test scores for all battleship personnel were similar to the Navy-wide and ship sample averages. Average performance evaluations for the E-5s through E-9s on board the battleships (including the gunner's mates and fire controlmen) were also similar to the Navy-wide and ship sample averages.

## Drug Use Incidence Is Lower Among Battleship Personnel

Drug use appears to be less of a problem aboard the battleships. The incidence of positive urinalysis results was lower among battleship personnel compared to the ship sample and Navy-wide personnel (see table 4.8).

**Table 4.8: Urinalysis Results** (Fiscal Year 1989)

| | Number of samples submitted | Number of positive samples | Percent positive |
|---|---|---|---|
| Iowa | 3,005 | 12 | 0.40 |
| Battleships | 14,118 | 190 | 1.35 |
| Ship sample | 21,468 | 336 | 1.57 |
| Navy-wide | 1,543,961 | 28,736 | 1.86 |

## Problems Noted in 16-Inch Gun Training Programs and Oversight

The Navy's investigation of the Iowa explosion raised concerns about the actual training provided Navy personnel through the advanced 16-inch gun training course and the shipboard personnel qualification standard program for turret personnel. The program identifies the specific knowledge and skills that an individual must demonstrate before he is considered qualified for duty positions throughout a ship. For example, in the 16-inch gun turrets, the program requires sailors to be knowledgeable of various safety precautions and procedures relating to the guns, ammunition, and equipment, as well as of the specific tasks that relate to their duty positions. However, the former commanding officer said that, prior to the explosion, review teams visiting the Iowa had identified no 16-inch gun-related training deficiencies.

We were unable to determine the training status of turret personnel at the time of the explosion. However, we did determine that external oversight inspections had not addressed the Iowa's 16-inch gun personnel qualification standard program for at least 18 months prior to the explosion. In addition, we found several problems associated with 16-inch gun training courses and their oversight. Navy courses that teach advanced job skills lacked realistic training aids, thereby, affecting the level of operations and maintenance skills provided. While options have been developed to enhance training, final decisions are pending because a battleship gun weapon system training plan has not been approved.

## Individual Qualification Training Status Prior to Explosion Unknown

The Navy's investigation of the explosion concluded that the Iowa's personnel qualification standard program for the 16-inch gun turrets was "suspect." The investigation reached its conclusion because available documents indicated that only a limited number of personnel were qualified for positions they held at the time of the explosion. The Iowa's former commanding officer said the crew was trained; however, the personnel records had not been updated to reflect the status of training. Since the training records were destroyed in the explosion, never existed, or have not been located, we were unable to reconcile this discrepancy. We found, however, that external oversight inspections that should have included an assessment of the Iowa's 16-inch gun personnel qualification standard program had not done so. The inspection teams either addressed other areas during their reviews or lacked the expertise to evaluate the program.

### Shipboard Documents Inconclusive as to Individual Personnel Qualification Standard Training Status

Although the Iowa had implemented a personnel qualification standard program for the personnel assigned to its turrets, sufficient records were not available after the explosion to establish the individuals' qualifications. The Navy's report criticized Iowa officials for not adequately documenting the qualifications of assigned personnel—especially making service record entries. However, at the time of the explosion, service record entries, while preferable, were not required to be made until personnel were transferred to another command. Since then, Navy regulations have been revised to require that such entries be made when a service member successfully meets the personnel qualification standards for a duty position. During our November 1989 review of service records for selected turret personnel on the Iowa, we found that the new requirement had been implemented.

Using reconstructed data, Iowa officials attempted to evaluate the qualification status of the crew assigned turret positions on the day of the explosion. Crew members were considered to be "operationally qualified" based on the number of gun fire exercises and training drills in which they had participated.

While that data indicated the degree to which the crew members had apparently participated in various exercises and live gun shoots, the data, in our opinion, did not demonstrate the crew members' actual proficiency. The data did not show the extent each person had performed the corresponding personnel qualification standard program exercises and drills for the positions held on the day of the explosion. For example, one person, classified as operationally qualified, was performing his assigned role during a firing exercise for the first time on

April 19. Another individual serving in turret II was not included in the analysis. However, the data did show that most of the crew in the turrets on the day of the explosion had participated in many live firing exercises.

## External Reviews Did Not Provide Status of 16-Inch Gun Personnel Qualification Standard Program Prior to Explosion

External reviews conducted on board the Iowa during the 18 months before the explosion that were to address weapons department training issues did not assess the Iowa's 16-inch gun personnel qualification standard program. The review teams emphasized other areas during the inspections or did not include members who were experienced in this gun system. The results of the reviews provided to the ship's commanding officer generally indicated that the program was satisfactory. However, the teams did not note that the 16-inch gun system was not included in the scopes of the reviews.

The combat systems assessment conducted 1 month before the explosion did not address the 16-inch gun personnel qualification standard training program, even though it was scheduled to and two experienced senior gunner's mates from the battleship Wisconsin were assigned to the assessment team. Much of the team's effort focused on helping the crew prepare for a material condition inspection scheduled for the following week. In addition, the team conducted cruise missile certifications concurrently with the assessment. The scope of the assessment was limited to reviewing the cruise missile personnel qualification standard program. Although the assessment report did not indicate the limits to the review's scope, and noted that the personnel qualification standard program was found to be satisfactory, the team leader stated that he had briefed the Iowa's commanding officer on the review's limitations.

Personnel from the Training Command, Atlantic Fleet, conducted a training readiness evaluation from September 1 to 2, 1988. The evaluation included a review of the personnel qualification standard program throughout the ship, but, as the coordinator noted, it did not include the 16-inch gun personnel qualification standard program because of the team's lack of experience in this gun system. Although the evaluation report did not indicate any problems in the weapons department program, it did not indicate that the 16-inch gun personnel qualification standard program had not been reviewed.

## Advanced 16-Inch Courses Provide Limited Training

The Navy's 16-inch gunner's mate, fire control, and turret officer courses, which teach advanced job skills, lack realistic training aids. As a result, the courses are not effective in providing actual hands-on operations and maintenance skills. In addition, few officers attended the turret officer course.

The 16-inch gunnery course provides little hands-on training for gunner's mates serving in key turret positions such as turret captain, turret repairman, and gun captain. The 8-week course is designed only to familiarize students with turret operations and maintenance. Training aids such as a replica of a 16-inch gun turret or any of its subsystems, powder bags, or projectiles are not available for use during the course to provide the students practical hands-on experience. Information is conveyed to the students through the use of manuals and audio-visual material such as overhead slides and films. The films date to the 1940s.

The fire controlman 16-inch gun fire control system course is also 8 weeks and is also taught without any technical training equipment. This course uses no films, and all information is conveyed through diagrams, schematics, and overhead slides.

According to school officials, Navy advanced training courses for weapon systems typically provide hands-on training in operations and maintenance. However, they said that the 16-inch gunnery courses taught at the San Diego training location are the only weapon system courses that do not have actual equipment on which to train.

We asked the gunner's mates on board the Iowa and the New Jersey for their views on the advanced course for 16-inch gunnery. They said that the training they received during the course provided little practical instruction because of the lack of equipment. They stated that most of their knowledge of 16-inch gunnery operations and maintenance came from daily work on board the ships.

The turret officer's course is a 5-day introduction to the theory of turret operations and safety procedures. However, only two officers graduated from the school during fiscal years 1988 and 1989, even though the school has the capacity to train 24 officers per year.

Both school and Navy Headquarters officials acknowledged the limitations of teaching without equipment, and they are considering program changes. One option being considered is to keep a turret operational aboard one of the two planned decommissioned battleships and to take

students on board for hands-on training. Another option is to use equipment from battleship spare inventories to reassemble working gun and related fire control system components, which would allow actual maintenance and operational training.

Navy officials stated that implementation of these options depends on approval of the draft battleship gun weapon system training plan. However, in light of the recent decommissioning plan for two battleships, maintaining this type of training for a limited community may not be feasible.

## Conclusions

The battleships had not received a comparable share of their authorized enlisted supervisory personnel and journeyman personnel, particularly in ratings associated with gun turret operations. In addition, battleships had been manned with officer and enlisted personnel who were less competitive for promotions, and battleship personnel experienced higher disciplinary rates compared to other Navy personnel. We believe, and Navy officials concurred, that shortages in supervisors may have contributed to the high level of disciplinary problems aboard battleships.

The Navy's training plan for the battleships' gun weapon system was still in draft, and its advanced training did not provide adequate hands-on training in 16-inch gun operations and maintenance. In addition, the turret officer course was not effectively used. Although we could not determine the actual training status of the Iowa's turret II personnel at the time of the explosion, we found that external oversight inspections had not reviewed the Iowa's 16-inch gun personnel qualification standard program.

## Agency Comments and Our Evaluation

DOD partially concurred with our assessment that a number of manning and training problems affected the Iowa and the other battleships. However, while it agreed with the data presented in the report, DOD did not agree with the ships selected for the sample, and it believed the analysis did not reflect the size and manpower intensive nature of the battleships. Because the battleships' crews are so much larger, and therefore have more redundancy and flexibility, than those of the other ships in the sample, it believed that the battleships can more readily absorb manpower shortfalls than ships with smaller crews. DOD provided data comparing manning by actual numbers, rather than by percentages, that it believes to be more revealing of the ships' status.

DOD also disagreed that the battleships were crewed with lower quality personnel and said that the Iowa and the other battleships were very close to the Navy's averages in key areas such as promotability and, taking the proportionally larger junior population aboard the battleships into account, discipline and retention. DOD also said that the results of our comparison of officer selection rates were misleading.

DOD agreed that systemic 16-inch gun training problems existed. However, it said that, at the time of the explosion, the Iowa had the required number of gunner's mates who had completed the formal 8-week 16-inch gun training course and that many of the training problems noted in the report have been corrected. The battleships' personnel qualification standards programs are now properly documented and verified by external inspection, and more officers have attended the turret officer course. While agreeing that the formal 16-inch gunnery course does not provide hands-on training, DOD said that the course is designed to be used with follow-on training aboard the ships and that it is thoroughly teaching 16-inch gun explosive safety requirements and precautions. DOD also said that a class training plan for the battleships was approved in 1983 and was in effect at the time of the explosion.

## Our Evaluation

We agree that the battleships' crews are larger than those on the ships in the sample. However, as discussed in chapter 1, at the suggestion and with the concurrence of senior officials in the Office of the Assistant Chief of Naval Operations for Surface Warfare, we limited the ships in the sample to those under that office's cognizance. Those officials agreed at that time that this methodology insured, to the extent practicable, the ships included in the sample were equipped with similar weapons systems, generally required the same mix of skills, and were subject to comparable manning decisions. We still believe that our methodology for selecting the sample was sound and that the data comparison shows there were distinct differences between the crew members of the battleships and of the ships in the sample.

While the personnel data DOD included in its comments show the total number of gunner's mates aboard the ships, the data do not show the status of authorized supervisory and journeymen gunner's mates. Thus, the data do not illustrate the degree to which lower ranking, less experienced personnel were required to perform duties calling for more experienced personnel as occurred on the Iowa. Also, according to a Navy official, the DOD data reflect varying dates for the ships' deployment

cycle—not the month of deployment we used in our analysis. Therefore, we cannot draw any meaningful conclusions from the additional data.

We disagree that the information DOD provided shows that the battleships were crewed with comparable quality personnel. Regardless of the Iowa's personnel aggregate score on the promotion advancement examinations for both fiscal year 1990 cycles, a significantly smaller percentage of the Iowa's gunner's mates and fire controlmen were promoted during the March 1989 cycle—the cycle closest to the Iowa explosion—than were promoted Navy-wide.

We agree that the demographics of a battleship's crew (a high percentage of lower ranking, younger personnel) affects the disciplinary rate. However, we also believe the shortage of supervisory personnel on the battleships has contributed to the higher disciplinary rates on those ships and makes that shortage even more serious.

While we agree that retention is an indicator of crew morale and satisfaction, we do not believe that retention is necessarily a measure of quality. For that reason, and with the concurrence of Navy officials, it was not one of the measures of quality we selected for our comparison. We believe DOD's data support the view that battleship duty is not desirable. The data show that retention rates aboard the battleships have steadily and significantly declined since fiscal year 1988, while the overall rate for the Navy and all surface ship rates have significantly increased during that period.

We disagree that our comparison of the rates at which officers were selected for more responsible positions was misleading. It is true that the only commanders aboard several of the ships in the sample are the ships' commanding officers and, thus by definition, have been selected for command at that grade level. That, however, is the point of the comparison. The commanders serving aboard the battleships were less frequently considered to be among those most qualified to command a ship, even after having been considered several times. The most qualified were already commanding ships. While DOD's data show that selection rates for battleship officers are more comparable to other ships, the data include fiscal year 1990 results. The information is not, therefore, as directly indicative of the officers serving aboard the ships at the time of the Iowa explosion as our information, which includes only 1989 data.

We believe that the advanced course for the 16-inch gun system, as currently structured, is of limited value. While, as DOD pointed out, Navy training audits have concluded that the course is adequately and thoroughly teaching explosive safety requirements and precautions, the December 1989 draft BB-61 Class Gun Weapon System Weapons Training Plan noted that apprentice and skill progression training provided by the course was not adequate to meet fleet requirements because of the lack of hands-on training equipment.

We have changed the report to reflect that the Gun Weapon System Training Plan for the BB-61 class has not yet been approved.

# Factors Supporting Battleship Decommissioning

Because the battleships are equipped with an array of weapons, both guns and missiles, they can attack both land targets and other surface ships. However, emerging circumstances, such as changing threats and military doctrine and budget constraints, limit these ships' use and make them candidates for deactivation.

## Battleship Capabilities and Missions

The battleships' primary missions of strike warfare and antisurface warfare involve attacks against both land targets and other ships. Battleships can operate as part of an aircraft carrier battlegroup or as the centerpieces of their own battlegroups that include other surface combatants with antiair and antisubmarine warfare capabilities. With their variety of guns and missiles, the battleships provide an imposing array of firepower. The Tomahawk missiles give the ships a significant capability for attacking land targets and other surface ships at long ranges. The Harpoon missiles contribute to the battleships' capability to attack hostile surface ships.

Of the guns in the Navy's inventory, the 16-inch guns are the best source of naval surface fire support for an amphibious assault and also are useful for attacking other land targets. They are, in fact, the only remaining guns on Navy ships that are larger than 5 inches. According to Navy officials, the 16-inch guns have some advantages over aircraft in attacking shore targets. When compared to air support in an amphibious operation, these guns, within their range limitations, can deliver more firepower under a wider variety of weather conditions. These guns also could have an advantage attacking shore targets in a crisis situation because the danger of losing an aircraft and its crew if it were shot down, as was the case in Lebanon in 1984, would not exist.

The Navy considers the battleships to be uniquely qualified for demonstrating U.S. resolve in crisis situations and goodwill and support for U.S. allies. The Navy believes that a battleship's imposing size and configuration can be a strong deterrent in a third-world conflict. Navy officials also believed that use of the battleships allows the United States to make a more measured response to a crisis situation. Since their reactivations, the battleships have been deployed throughout the world.

## Limitations

While the battleships have a broad range of capabilities, evolving changes in the weapons systems carried on board other ships and military doctrine limit the battleships' usefulness. Even though, for example, the battleships' Tomahawk and Harpoon missiles' capability is

imposing, it is not unique within the Navy. Many other Navy vessels, submarines as well as surface combatant ships, and also aircraft in the case of Harpoon, are now equipped to carry the same weapons.[1]

The range limitations of the 16-inch guns (the battleships' one unique weapon system) impair the guns' ability to support amphibious warfare operations. While a projectile with a longer range than the current maximum range of over 23 miles is under development, the guns' current maximum range limits the ships' ability to provide effective naval surface gun fire support. Other limitations such as the types of projectiles currently available also exist.

Current military doctrine calls for amphibious assaults to be launched from "over the horizon"—25 to 50 miles offshore—and to extend far inland. This concept allows (1) U.S. forces to exploit the speed and mobility of modern aircraft and landing craft and (2) a larger degree of tactical surprise because the assault is launched from further offshore than was previously the case, thus the enemy is less certain where the actual landing will occur. The concept also reduces the vulnerability of the amphibious task force to the effects of modern weapons such as precision guided munitions. Traditional pre-assault operations, such as a concentrated shore bombardment, may also be restricted or severely curtailed to achieve tactical surprise.

There are two primary fire support requirements during an "over the horizon" assault. The first, during the initial phase of the assault, is to neutralize any remaining beach defenses and engage enemy forces that threaten helicopter landing zones. The second, which occurs as the assault progresses, is to attack enemy forces as they attempt to mass and counterattack.

The battleships' ability to rapidly respond to future crises will be reduced. With only two battleships remaining in an active status, peacetime operating and personnel tempo restrictions will limit future deployments. Current policies, for example, preclude a ship from redeploying for 12 months after it returns from a 6-month deployment. Thus, with only two ships in the active force, it is less likely one would be deployed and, therefore, available on short notice should a crisis erupt.

[1]We pointed out in a September 19, 1985, letter addressed to the Chairman, Subcommittee on Defense, Senate Committee on Appropriations, that, as new Navy ships were built and others were modernized, many ships besides the battleships would be equipped with Tomahawk missiles.

The battleships are also labor intensive compared to other Navy surface combatant ships. They require a crew of about 1,500 compared, for example, to a crew of about 360 on an Aegis cruiser. According to a Navy document, the battleships cost about $58 million each to operate annually. These operating costs contributed to the decision by the Secretary of Defense to decommission two battleships. That decision was not affected by the subsequent Iraqi invasion of Kuwait.

Finally, the Navy, responding to the Secretary of Defense's direction to decommission two of the battleships during fiscal year 1991, has decided to decommission the Iowa and the New Jersey. Reducing the number of battleships to two, especially with one homeported on each coast as currently planned, will compound the manning and training problems discussed earlier (see ch. 4).

While the Missouri and the Wisconsin were deployed to the Middle East as part of the U.S. military response to the Iraqi invasion of Kuwait, their contribution to amphibious assault operations in that arena cannot be measured at this time.

## Conclusions and Recommendation

As the world security environment changes, because ships other than battleships have an excellent strike warfare capability and because of limits on the battleships' ability to support a large scale amphibious assault, the Navy's need to maintain the battleships is questionable. The planned decommissioning of two battleships, including the Iowa, also raises questions about the usefulness and supportability of the other two ships in the active fleet. A deployed battleship's presence in overseas theaters will be limited because of the effect of peacetime operating and personnel tempo restrictions on the two remaining battleships. Manning and training problems will also be compounded by a smaller pool of experienced 16-inch gun-related personnel.

Budget constraints led to the decision to decommission two of the four battleships. The battleships are costly to maintain and difficult to man (see ch. 4) and, until the ships' unique contributions in the Middle East can be evaluated, mission-related questions concerning their contributions remain.

For these reasons, we recommend that the Secretary of Defense direct the Secretary of the Navy to reevaluate the battleships' usefulness in the light of known constraints and limitations and, unless current Middle East operations convincingly demonstrate their unique utility in

support of an amphibious assault, to decommission the U.S.S. Missouri and the U.S.S. Wisconsin.

## Agency Comments and Our Evaluation

DOD, while partially concurring with our conclusions concerning the limitations of the battleships' usefulness, concurred with our recommendation. It agreed that the ships are manpower intensive and said it was currently reviewing the other factors we discussed concerning the battleships' limitations. It said, however, the battleships still have a useful role in amphibious assault operations. Once the forces are ashore in an amphibious assault, the battleships could move landward and thus could provide needed gunfire support. DOD also said, peacetime operating and personnel tempo restrictions aside, the remaining two battleships can still respond rapidly to crisis situations because of their speed and endurance. In concurring with the recommendation, DOD said that the battleships' future should not be based solely on Persian Gulf or Arabian Sea operations with their unique geography, noting the shallow water environment.

## Our Evaluation

We agree that the battleships may be able to move within range to provide fire support after a landing force is ashore. However, at that point in a large-scale assault, landing force field artillery assets and Marine Corps tactical aircraft will also be able to provide fire support. Therefore, the unique contribution of the battleships' 16-inch guns becomes increasingly that of providing longer range fire support under adverse weather conditions.

We also agree that the remaining two battleships could respond in times of crisis. However, their role becomes more of responding to a crisis than deterring a crisis through an overseas presence.

Our recommendation was not intended to imply that the battleships' contributions to current Middle East operations should be the sole criteria for their retention, only that those contributions should not be excluded from consideration.

# Comments From the Department of Defense

ASSISTANT SECRETARY OF DEFENSE

WASHINGTON, D.C. 20301-4000

FORCE MANAGEMENT
AND PERSONNEL

13 DEC 1990

Mr. Frank C. Conahan
Assistant Comptroller General
National Security and
International Affairs Division
U.S. General Accounting Office
Washington, D.C. 20548

Dear Mr. Conahan:

This is the Department of Defense (DoD) response to the General Accounting Office (GAO) Draft Report, "BATTLESHIPS: Issues Arising From the Explosion Aboard the U.S.S. Iowa," dated October 26, 1990 (GAO Code 394339, OSD Case 8354-A). The DoD generally concurs with the GAO findings and recommendations.

Additional information is provided in several areas to increase the accuracy of the report. With regard to the technical analyses of the explosion itself, work is still underway. Final results will be reported in conjunction with the follow-on GAO review, "Navy's Reopened Investigation of the U.S.S. IOWA Explosion" (GAO Code 394380). The DoD is, however, confident that the two remaining battleships in active service are safe to operate and, if required, will provide significant support to the mission in the Persian Gulf. The detailed DoD comments are provided in the enclosure. The DoD appreciates the opportunity to review the draft report.

Sincerely,

Christopher Jehn

Enclosure:
As Stated

**GAO DRAFT REPORT - DATED OCTOBER 26, 1990
(GAO CODE 394339) OSD CASE 8354-A**

**"BATTLESHIPS: ISSUES ARISING FROM THE EXPLOSION ABOARD THE U.S.S. IOWA"**

**DEPARTMENT OF DEFENSE COMMENTS**

* * * * *

**FINDINGS**

Now on pp. 2, 8-10.

- **FINDING A: NAVY INVESTIGATION OF EXPLOSION.** The GAO reported that, on April 19, 1989, five bags of propellant ignited in an open chamber of a 16-inch gun of turret II on the U.S.S. IOWA and 47 sailors died in the resulting fire and explosion. The GAO observed that the Navy investigating officer concluded that the explosion most probably resulted from a deliberate act and not from a defect in the gun or propellant. The GAO ascertained that the investigator's conclusion was based upon information developed by a technical support team, as well as by the Naval Investigative Service. The GAO observed that the Navy based its findings on an analysis of chemical elements and other material found on the rotating band of the projectile that lodged in the gun barrel, which it considered to be evidence of an explosive device. The GAO further observed that the Navy also relied on a psychological analysis the Federal Bureau of Investigation prepared, which indicated a crew member was capable of making and using such a device. As a part of its evaluation of the explosion incident, the GAO requested that the Sandia National Laboratory review the Navy technical analysis. (p. 2, pp. 8-12/GAO Draft Report)

  **DOD RESPONSE:** Partially Concur. Immediately after the tragedy aboard the U.S.S. IOWA, the Navy began an extensive investigation to determine the cause of the explosion. The technical investigation team initially considered seven possible basic accidental causes for the explosion--(1) friction, (2) flame, (3) compression, (4) impact, (5) electrostatic discharge, (6) electromagnetic radiation, and (7) the characteristics of the ammunition. The Navy conducted thousands of tests and reviewed all aspects of the 16-inch gun operation. Many possible accidental causes of the explosion were considered and dismissed because no evidence supported them. The investigating officer later expanded the scope to include the possibility that a deliberate act caused the explosion. The investigation was then enlarged to include analysis of the chemical elements and foreign materials found on the rotating band of the

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projectile and the psychological analysis by the Federal Bureau of Investigation. The Navy technical investigation findings concluded there was no evidence of any defect or malfunction of the gun or propellant:

- All of the tests and analyses conducted on the propellant and black powder components of the bag charges indicated normal sensitivity and stability characteristics.
- All of the tests and analyses conducted on the bag charges using various ignition scenarios, failed to identify any probable accidental causes.
- All evidence showed that the gun, the ramming system, and the other mechanical components of the turret were in acceptable working order at the time of the incident.

- **FINDING B: Chemical and Impact Sensitivity Issues.** The GAO reported Sandia could neither confirm or deny the Navy conclusion that foreign material residue on the rotating band was evidence of a chemically activated detonator device. The GAO further reported Sandia concluded that, in fact, the foreign materials the Navy found were consistent with the nominal levels found in gun turrets in a salt water environment. For example, the GAO explained that calcium and chlorine--two constituents of the detonator postulated by the Navy--were readily detectable in both turrets I and II of the U.S.S. IOWA, as well as on other battleships. In addition, the GAO reported that, while agreeing with the Navy investigation report (i.e., that the powder was chemically stable and confirmed that a significant overram of the powder charge occurred), Sandia identified a plausible alternative explanation for the explosion--that the powder ignited because it was rammed against the base of the projectile. The GAO advised Sandia believed the probability of that process occurring depended on the speed of the overram and the number of pellets in the powder bag's top layer. The GAO noted Sandia recommended that (1) 16-inch guns be equipped with a mechanism to control the speed of the rammer and the placement of powder bags, (2) the powder bags be redesigned, and (3) further testing be conducted. The GAO observed that, as a result, the Navy began a series of tests on full sized powder charges (some of which resulted in powder ignitions). The GAO also observed that the Navy took additional action, as follows:

  - suspended firings of the 16-inch guns
  - reopened its investigation; and

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Now on pp 2-3 19-22.

- began exploring safety modifications to the 16-inch gun. (pp. 2-3, pp 24-30/GAO Draft Report)

**DOD RESPONSE:** Partially concur. Foreign material residue and Sandia's alternative hypothesis for the explosion remain under investigation by the ongoing Naval Sea Systems Command technical review. The technical review is being conducted in conjunction with the Sandia National Laboratories, the U.S. Army Ballistics Research Laboratory, and appropriate Navy activities. It is, therefore, premature to address any conclusions from this phase of the testing, since they still remain to be drawn.

The Navy suspended the firing of the 16"/50 guns when test results indicated even a remote possibility of an ignition as a result of a high speed overram if there were only a few propellant grains in the trim layer of a powder bag charge. The Navy took the following steps to ensure the safe use of the 16"/50 gun systems.

- Established safe levels for the number of propellant grains in the trim layer of the two types of full charge.
- Conducted a 100 percent inspection of all bag charges on the U.S.S. WISCONSIN and U.S.S. MISSOURI (the two remaining battleships deployed in the Persian Gulf) to ensure that all usable charges met the safe levels; any charges not meeting the requirement were rejected for use.
- Conducted a complete inspection of each 16"/50 gun turret to ensure full and safe operation.
- Placed a yellow mark on the rammer handle bracket to identify the proper position for a powder ram.
- Reopened the investigation and is continuing to conduct tests and analyses in close cooperation with Sandia in order to explore areas of foreign material and possible accidental causes.

- **FINDING C: Powder Stability, Ammunition, Serviceability and Safety.** The GAO found no indication of any chemical stability problems or other problems with the specific type of propellant involved in the explosion. The GAO also reported that battleship equipment failure reports disclosed no systemic material problems with the ships, in general--or with the guns, specifically. The GAO ascertained that, when compared to similar data on other types of ships in 1987 and 1988, the battleships did not present any undue problems of maintenance or supply. The GAO also found that battleship

personnel experienced no systemic ammunition or gun problems. The GAO noted that the Navy investigation report found some safety violations on board U.S.S. IOWA, and a subsequent investigation by the Navy Inspector General confirmed that ship personnel were conducting improperly approved experimentation of projectile and gunpowder combinations on the day of the incident. (The GAO emphasized however, that both reports concluded the experimental combinations did not cause the explosion.) (p. 4, pp. 31-39/GAO Draft Report)

Now on pp. 3-4, 23-28.

**DOD RESPONSE:** Concur. The combination of five D846 configuration bag charges with a 2,700 pound projectile had not been tested by the Navy nor approved for fleet use. However, the D846 bag charge design and the propellant used to load them were service approved. Tests and analyses conducted subsequent to the U.S.S. IOWA explosion have determined that the gunnery testing on U.S.S. IOWA did not expose the crew or ship to any safety or testing risk beyond that of normal 16"/50 gunnery.

- **FINDING D: Manning.** The GAO found that the U.S.S. IOWA, specifically, and the battleships, generally, were assigned a disproportionately low percent of enlisted supervisory personnel--particularly those responsible for operating the turrets (see report table 4.1). The GAO also corroborated the perception of the former IOWA commanding officer that the quality of manning on battleships was lower than for naval ships on the average. For example, the GAO found that battleship personnel were promoted at lower rates and experienced higher disciplinary rates than personnel assigned to a sample of other naval ships (see report tables 4.2 and 4.3). The GAO observed, and reported Navy officials agreed, that the shortages in supervisors may have contributed to the high level of disciplinary problems aboard battleships. (pp. 3-4, pp. 40-52, p. 60/GAO Draft Report)

Now on pp. 3-4, 29-36, 40.

**DOD RESPONSE:** Partially concur. The DOD agrees with factual number and percentage data presented by the GAO. The DoD does not, however, agree with the GAO ship sample selection or analysis of the data, as applied to manning. It is the DoD position that the GAO should consider additional information, which provides further insights into the manning of the battleship Gunners' Mates and Fire Controlman ratings, as well as the overall manning of the battleship.

Much of the GAO data analysis that has been publicized in support of the criticism of the quality and quantity of IOWA manning is misunderstood, misleading and unfair to those who serve aboard Navy battleships. The size of the

battleship and its manpower intensive nature influences the way in which IOWA manning should be studied. The battleships, with crew requirements of nearly 1,500 personnel, are five times as large as modern destroyers and half again as large as amphibious vessels. The very size of the crews allows for a certain redundancy and flexibility in personnel assignment. Modern, smaller ships, on the other hand, have been designed to require fewer people. As an example, the IOWA had an allowance of 11 gunners' mates in pay grades E-7 - E-9, whereas the USS INGERSOLL (DD-990) is authorized only one and the cruiser JOSEPHUS DANIELS (CG 27) has an allowance of two.

The impact of manpower shortfalls, while significant under any circumstance, can be absorbed more readily by ships with larger crews. Consequently, a comparison of ship manning by actual numbers is more revealing than by percentages, when comparing ships of significantly different sizes and complexities, as in the following table:

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Manning of Gunner's Mate Billets
Authorized vs. Assigned Personnel
for Selected USN Combatants

| Ship | Billets Authorized | Personnel Assigned |
|---|---|---|
| Battleships: | | |
| USS IOWA (BB-61) | 99 | 87 |
| USS NEW JERSEY (BB-62) | 99 | 77 |
| USS MISSOURI (BB-63) | 83 | 89 |
| USS WISCONSIN (BB-64) | 83 | 82 |
| Cruisers: | | |
| USS J. DANIELS (CG-27) | 8 | 7 |
| USS WAINWRIGHT (CG-28) | 8 | 10 |
| USS STANDLEY (CG-32) | 9 | 9 |
| USS FOX (CG-33) | 9 | 11 |
| USS BIDDLE (CG-34) | 9 | 10 |
| Destroyers: | | |
| USS SPRUANCE (DD-963) | 8 | 11 |
| USS PAUL FOSTER (DD-964) | 7 | 7 |
| USS HEWITT (DD-966) | 7 | 8 |
| USS COMPTE DE GRASSE (DD-974) | 7 | 7 |
| USS MERRILL (DD-976) | 10 | 12 |
| USS CONNOLLY (DD-979) | 7 | 6 |
| USS JOHN RODGERS (DD-983) | 9 | 7 |
| USS LEFTWICH (DD-984) | 9 | 9 |
| USS INGERSOLL (DD-990) | 7 | 5 |
| Helicopter Assault Ships: | | |
| USS SAIPAN (LHA-2) | 14 | 14 |
| USS BELLEAU WOODS (LHA-3) | 8 | 7 |
| USS NASSAU (LHA-4) | 8 | 8 |
| USS PELELIU (LHA-5) | 8 | 9 |

The GAO contends that the Navy sent lower quality enlisted personnel to the IOWA and the other battleships. One reason cited was that there were difficulties in filling journeyman and supervisory billets on battleships. Although the Navy assigns personnel based on a number of factors, including personal preference, that does not restrain the assignment of personnel where their skills are required.

When compared to similar large ships with large percentages of junior personnel, such as aircraft carriers,

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or helicopter assault ships, the IOWA and other battleships were very close to the Navy average in key areas of promotability, discipline, and retention.

The Navy enlisted advancement system is based on results from standardized examinations for each rating, which are given twice each year in March and September. The battleship advancement score (for all ratings on board) were less than one percentage point below the fleet average for both examination cycles for 1989. For that full year, the average battleship advancement score was 49.13 compared to the fleet average of 50.0. While average score of the IOWA was the lowest of all battleships, it was within 1.4 points at 48.6, which is not a significant difference.

There is a misunderstanding of how the demographics of a large ship influence such numbers. The Non-judicial punishment rates must be viewed in the context of crew seniority. The comparison should not really include the officers and senior career enlisted personnel in the data, since non-judicial punishment is most unusual for them. For example, the IOWA and other battleships are manned with higher percentages of junior personnel in relation to the Navy as a whole; between 70 - 74 percent of the crew are E-1 - E-4. The newer high-technology ships are manned to about 57 percent E-1 - E-4 personnel. By and large, it is the younger E-1 - E-4 population where higher non-judicial punishment rates are encountered--and would be expected to encountered.

In the table below, the impact of a large junior crew is evident:

NON-JUDICIAL PUNISHMENT RATES VS. SHIP TYPE AND CREW SENIORITY

| Ship type | E-1 - E-4 Percent of crew | Non-Judicial Punishment/1000 |
|---|---|---|
| DESTROYERS | 56.9 | 142 |
| CRUISERS | 62.6 | 170 |
| HELICOPTER ASSAULT SHIPS | 64.0 | 163 |
| AIRCRAFT CARRIERS | 68.6 | 184 |
| U.S.S. IOWA | 70.2 | 173 |
| BATTLESHIPS | 73.7 | 195 |

The following chart shows the impact in a more pronounced manner. Connecting the point on the graph would have a very strong correlation, indicating the connection between a junior crew and an anticipated increase in Non-judicial punishment cases. Accordingly, the discipline on the IOWA was not worse, but actually better than could have been predicted.

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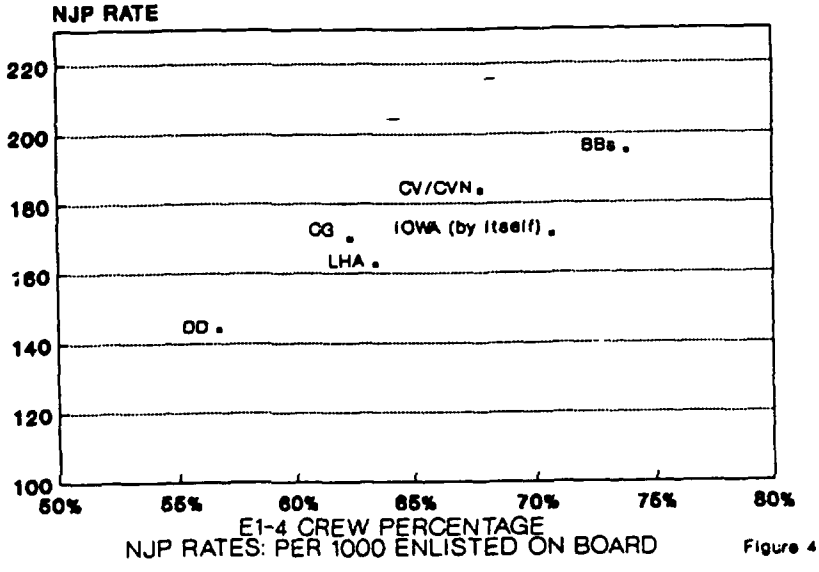


Figure 4

Another very valuable indicator of crew morale and satisfaction is retention. Using that criteria, the IOWA and other battleships reflect typical fleet units that are sometimes above/sometimes below the average, but not alarmingly so. The following table indicates the IOWA to be generally above the other battleships, but somewhat below "All Surface Ships" or "All Navy" retention figures:

| | Selected Gross Navy Retention Rates (1st, 2nd and 3rd term combined) | | | |
|---|---|---|---|---|
| | FY-87 | FY-88 | FY-89 | FY-90 (thru Apr) |
| U.S.S. IOWA | 35.4 | 45.4 | 40.4 | 36.5 |
| All Battleships | 29.0 | 42.8 | 37.3 | 37.1 |
| All Surface Ships | 45.3 | 44.9 | 48.6 | 52.0 |
| All Navy | 47.1 | 46.5 | 49.2 | 52.7 |

When viewing the data, keep in mind that the proportionally larger junior population aboard battleship lowers their overall retention rates, since the first term retention category is always significantly lower than second and third

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term retention rates. The battleship retention rate is further disadvantaged because battleship crews receive less of a retention incentive from Selected Retention Bonuses which are generally targeted to the highly technical skills. A battleship has approximately 25 percent of the crew receiving Selected Retention Bonuses at some level, whereas about 34 percent of an Aegis cruiser receives Selected Retention Bonuses.

Older, manpower-intensive ships, such as IOWA, with large numbers of very young and junior personnel, are very different from the newer, high technology ships with a larger percentage of mid-grade and senior technically trained petty officers. That needs to be taken into account in the analysis.

Assignment to a battleship for an officer is not a career disabling event. Published comparisons of the rates at which battleship officers and officers assigned to other kinds of ships screened for future Commander command or department head assignment have been portrayed as evidence of a lower quality officer aboard the battleships. Those comparisons are misleading. The grouping of ships against which battleships were compared included ten smaller ships, where the only Commander aboard is already a commanding officer, thus giving that ship a 100 percent selection rate. The executive officers of four additional ships used in the sample, required a Commander, who had already had command, further skewing an unfortunate and incorrect comparison. When the billets requiring command screen are accounted for, and including the results of the FY 1990 selection board, four of the 13 commanders assigned to battleships have been command-selected and seven more are still in zone for future consideration. Their selection rate of 23.1 percent is comparable with the 29 percent selection rate for commanders in non-command or post command positions in the entire sample. Eleven of the 19 Lieutenant Commanders in battleships are executive officer screened and seven are still in zone for consideration. The screening rate for battleships is now 52.6 percent. The IOWA has two of four officers selected for a rate of 50 percent. Other Lieutenant Commanders (not already assigned to executive officer billets) in the ships sampled have a selection rate of 31 percent. Assignment to a battleship is, therefore, not injurious to an officer's career.

- **FINDING E: TRAINING.** The GAO noted the former commanding officer of the IOWA maintained that his personnel were adequately trained on the day of the explosion. The GAO observed, however, that the Navy investigation report concluded they were not. The GAO also observed that, because training records were destroyed in the explosion,

Now on pp. 3-4, 29, 36-40.

never existed, or have not been located--it could not reconcile those two statements. The GAO also found that external oversight inspections had not reviewed the IOWA 16-inch personnel qualification standard program. In addition, the GAO found that the Navy had not approved a training plan for the battleships--and that the advanced training school provided only limited hands-on training aids for operations and maintenance instruction on the 16-inch guns. The GAO also found that the turret officer course was not used effectively. The GAO concluded that there were systemic problems with the Navy training for 16-inch gun operations. (P. 3, p. 5, pp. 40-41, pp. 53-51/GAO Draft Report)

**DOD RESPONSE:** Partially concur. The DOD agrees that reconciliation of the difference in the commanding officer's view of the adequacy of training, and the conclusion of the Navy investigation report (which concluded that training was not adequate), is difficult in view of the lack of records. The formal Navy (enlisted) training requirements at the time of the explosion had been met. The 16-inch gun training requirement for the IOWA at the time of the explosion was for 16 gunner's mates to have completed the formal eight week 16-inch 50 caliber gun system training course. Seventeen gunner's mates, who had successfully completed that course, were on board the IOWA at the time of the explosion. In addition, the IOWA commanding officer asserted in a Senate Armed Services Committee hearing on December 11, 1989, "IOWA was and is well trained, men had skill, training and experience to perform assigned tasks."

The DoD agrees that external oversight inspections had not documented the status of the IOWA 16-inch gun Personnel Qualification Standard training prior to the explosion. The GAO report concluded that shipboard documents were inconclusive as to the individual Personnel Qualification Standard Training status. The IOWA had implemented a personnel qualification standard program for the personnel assigned to its turrets but insufficient records were available after the explosion to establish the individuals' qualifications. The GAO goes on to explain, "... at the time of the explosion, service record entries....were not required to be made until personnel were transferred to another command." Since then, Navy instructions have been revised to require that such entries be made when a service member successfully meets the personnel qualification standards for a duty position. In September 1989, Fleet Commanders reviewed the status of the gunnery Personnel Qualifications Standard programs on all four battleships and certified that they were properly installed, operating effectively, and thoroughly documented. Additionally, during a November 1989 review of service records for

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selected turret personnel on the IOWA, GAO found that the new documentation requirements had been implemented.

The DoD does not agree that the Navy had not approved a training plan for the battleships. An approved 1983 Navy Training Plan for IOWA class battleships was in effect at the time of the explosion and adequately addressed training for the 16-inch guns.

The DoD agrees that the advanced training school (for the 16-inch gun system) did not provide hands-on training. The course is designed to be used with follow-on onboard training to provide the technical knowledge required to operate and perform maintenance on the 16"/50 gun system under limited supervision. The Navy Enlisted Classification Code GM-0875 is awarded upon recommendation of the commanding officer after fleet experience is obtained. That was because of the difficulty and expense of acquiring and installing a 16-inch gun training platform at the training site. Early in the battleship recommissioning program, analysis of training requirements showed that a formal academic course, which thoroughly covered the safe operations and maintenance of the 16-inch gun, coupled with the Personnel Qualification Standards and on-the-job training aboard the ship, would provide effective and adequate training to operate and maintain the 16"/50 gun system safely. In January 1990, Naval Sea Support Center Pacific conducted a technical training audit of the formal course, which included interviews of key personnel at the school, evaluation of the curricula and lesson guides, and observation of classroom instruction. The auditors concluded "...the explosive safety requirements and precautions (for the 16-inch gun system) are being taught thoroughly and with adequate emphasis."

The DoD agrees that the Turret Officer Course was not used effectively. The turret officer killed in the IOWA explosion had not attended the Turret Officer Course. Turret officer training is properly watchstation assignment training and, as such, each battleship was responsible to ensure officers assigned to the turret officer watchstation obtained the training. Since the explosion, attendance at the Turret Officer Course has been increased and the remaining battleships have an ample amount of graduates to man turret officer watchstations.

In summary, the DoD agrees that there were "systemic" problems with the Navy training for 16-inch gun operations, namely problems with documentation of Personnel Qualification Standards shipboard training (since corrected), under utilization of the Turret Officer Course (since corrected), and the impracticality of installing

"hands-on" 16-inch gun training devices at the school site.

Since the U.S.S. IOWA explosion, the Navy has examined and re-examined the adequacy of gunnery training. The DoD considers the Navy gunnery training to be sound and producing personnel who can safely operate the 16-inch guns.

- **FINDING F: Factors Supporting Battleship Decommissioning.** The GAO reported that, in the early 1980s, the Navy reactivated the battleships as a quick, near-term relief for force structure shortfalls. The GAO found that one of the principal missions of the battleships was to provide naval gunfire support for amphibious assaults. The GAO observed that, with their variety of guns and missiles, the battleships provide an imposing array of firepower. The GAO observed that, in addition to its 16-inch guns, the ships are equipped to carry 32 TOMAHAWK missiles and 16 HARPOON missiles. The GAO advised that, of the guns in the Navy inventory, the 16-inch guns are the best source of naval gunfire support for an amphibious assault and are useful against other land targets. The GAO pointed out that within their range limitations these guns can deliver more firepower under a wider variety of weather conditions than can aircraft--with the added advantage that aircraft crews are not put at risk in a crisis situation or in a major battle. The GAO found, however, that even though the battleship missile capability is imposing, it is not unique within the Navy--as other ships have those weapons. Further, the GAO advised that while a 16-inch projectile with a longer range than the current 23 miles is under development, the current range limits the ship's ability to provide naval gunfire to support amphibious operations. The GAO explained that is because current military doctrine calls for amphibious assaults to be launched from "over the horizon" to exploit tactical surprise and the related uncertainty as to where the actual landing(s) will occur. The GAO observed that concept also reduces the vulnerability of the amphibious task force to modern weapons.

  The GAO also found that the battleships are labor intensive, requiring a crew of about 1,500. The GAO further noted that, according to Navy documents, each battleship costs about $58 million annually to operate. The GAO noted that the Secretary of Defense had directed the Navy to decommission two battleships during FY 1991. The GAO observed that, with only two battleships, their ability to respond rapidly to crisis situations will be reduced--and peacetime operating and personnel tempo restrictions will limit deployments. The GAO also found that the planned homeporting of one battleship on each coast will further limit availability and will compound manning and training

problems. The GAO observed that, while the WISCONSIN is deployed to the Middle East, its contributions cannot be measured at this time. The GAO concluded that the battleships are costly to maintain and difficult to man. The GAO also concluded that, as the world security environment changes, because ships other than battleships have an excellent strike warfare capability and because of limits on the battleships' ability to support a large scale amphibious assault--the need to maintain the battleships is questionable. The GAO further concluded that the planned retirement of two battleships raises questions about the usefulness and supportability of the other two ships in the active fleet.

**DOD RESPONSE:** Partially Concur. The DoD agrees that the battleships are manpower intensive. The above Finding F includes factors that are currently under review within the Department of Defense. They will be taken into consideration in the decision to retain or deactivate the last two battleships.

Furthermore, although the over-the-horizon capability reduces the vulnerability of the amphibious task force, troops landing on the beachheads are still subject to the threat against which the 16-inch gun is the most capable. Modern amphibious warfare has provided the technological capability to reduce the probability of attack on the ships launching the assault, but the danger to forces coming ashore remains. Pre-assault support during over-the-horizon operations will depend heavily on tactical aircraft due to range limitations of the 16-inch guns. Once forces are projected ashore, however, the battleships would move landward to provide continuous and extensive fire power under all weather conditions. The 16-inch gun provides the only naval surface fire support capability in support of the over-the-horizon concept. With no replacement naval surface fire support system identified or programmed, the current 16-inch improvement program offers the most expeditious, as well as practical, interim solution to the naval surface fire range requirement in support of over-the-horizon operations.

Reducing the battleship force to two ships does not limit their ability to respond rapidly to crisis situations. Although peacetime operating and personnel tempo restrictions may limit routine deployments, the two remaining battleships, like any Navy ship, can get underway and respond to a crisis within hours. The battleships, with their unique speed (greater than 30 knots) and endurance (unrefueled range of 15,000 miles at 17 knots), can transit quickly to where they are needed. Contrary to the GAO assessment, the assignment of a battleship on each coast

allows the Navy to exploit the battleship mobility in responding to crises throughout the world.

In the current security environment, the battleship provides additional flexibility in the structuring of naval forces to meet the full spectrum of requirements.

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**RECOMMENDATION**

Now on pp. 5, 46-47.

- **RECOMMENDATION:** The GAO recommended that the Secretary of Defense direct the Secretary of the Navy to re-evaluate the utility of the battleship in the light of known constraints and limitations and, unless current Middle East operations convincingly demonstrate their unique utility, direct that the Secretary of the Navy decommission the U.S.S. MISSOURI AND THE U.S.S. WISCONSIN. (p.5, p.67/GAO Draft Report)

**DOD RESPONSE:** Concur. The Department of Defense recognizes the need to evaluate naval force structure and the utility of all ships on a continuing basis, including the two remaining battleships. However, the future of the battleships should not be based solely on operations in the Persian Gulf or the Arabian Sea (a shallow water environment) with its unique geography.

The Department of Defense is currently reviewing retention of battleships with respect to their capabilities and affordability in view of fiscal and manpower constraints. The results of that review are expected to be reflected in the FY 1992/FY 1993 President's budget.

# Activities Visited

In the Washington, D.C. area, we conducted our review at the following organizations.

- Office of the Chief of Naval Operations.
- Navy-Marine Corps Appellate Review Activity.
- Headquarters, U.S. Marine Corps.
- Headquarters, Naval Sea Systems Command.
- Headquarters, Naval Supply Systems Command.
- Naval Military Personnel Center.

In the Norfolk, Virginia, area, we visited the following activities.

- Headquarters, U.S. Atlantic Fleet.
- Headquarters, Naval Surface Force, U.S. Atlantic Fleet.
- Navy Manpower Analysis Center.
- Naval Safety Center.

We also visited the following activities and battleships.

- Headquarters, U.S. Pacific Command, Pearl Harbor, Hawaii.
- Headquarters, U.S. Pacific Fleet, Pearl Harbor, Hawaii.
- Naval Ordnance Station Indian Head, Maryland.
- Naval Surface Warfare Center Dahlgren, Virginia.
- Naval Warfare Support Center Crane, Indiana.
- Norfolk Naval Shipyard, Portsmouth, Virginia.
- Enlisted Personnel Manpower Analysis Center, New Orleans, Louisiana.
- Fleet Training Center, Pacific, San Diego, California.
- U.S.S. Iowa.
- U.S.S. New Jersey.
- U.S.S. Wisconsin.

We also met with representatives of the following command and activity.

- Naval Ordnance Station, Louisville, Kentucky.
- Headquarters, Fleet Marine Force, Pacific, Pearl Harbor, Hawaii.

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